

**Dietary Exposure of Mink (*Neovison vison*) to  
Fish from the Upper Hudson River, New York,  
USA: Effects on Reproduction, Offspring  
Growth, Mortality, Organ Mass and Pathology**

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# Outline

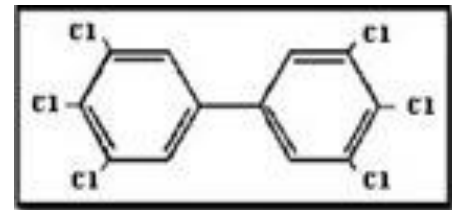
- **Polychlorinated Hydrocarbons**
- **2,3,7,8-Tetrachlorodibenzo-*p*-dioxin (TCDD)-like chemicals**
- **Toxic equivalency (TEQ) approach**
- **Why mink?**
- **Hudson River study**
  - **Introduction**
  - **Methods**
  - **Results**
  - **Summary and Conclusions**

# Polychlorinated Hydrocarbons

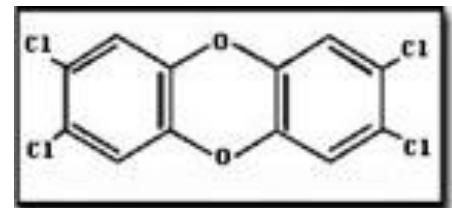
- **Include**
  - Polychlorinated biphenyls (PCBs)
  - Polychlorinated dibenzo-*p*-dioxins (PCDDs)
  - Polychlorinated dibenzofurans (PCDFs)
- **PCBs, PCDDs, PCDFs as environmental contaminants**
  - Widespread
  - Persistent

# Polychlorinated Hydrocarbons

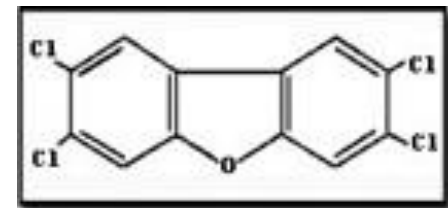
- PCBs, PCDDs, PCDFs grouped together because of similarities in:
  - Structure
  - Mechanism of action and toxic effects
  - Occurrence in environment



3,3',4,4',5,5'-hexachlorobiphenyl



2,3,7,8-tetrachlorodibenzo-*p*-dioxin



2,3,7,8-tetrachlorodibenzofuran 5

# PCBs

- **Commercially produced in US by Monsanto**
- **1.4 billion lbs from 1930-1975**
- **90% used in US**



# PCBs

- **Used as nonflammable oils**
  - Transformers
  - Condensers
  - Paints



# PCBs

- **Used as**
  - **Plasticizers**
  - **Flame retardants**
  - **Electrical insulators in small appliances**
  - **Suspension vehicle for pigment in carbonless copy paper**
  - **Microscope immersion oil**

[illegible]



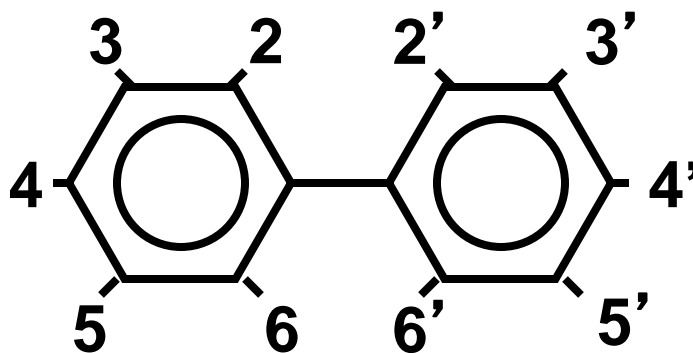
# PCBs

- Production for open-ended uses ended in 1971
- Production ceased completely in 1977
- 54% still in use
- 31% in the environment



# PCBs

- **Commercial PCB products (Aroclors)**
  - **15 Aroclor products**
    - Aroclors 1242,1248,1254,1260
  - **Complex mixtures of individual congeners**



**209 Congeners**

# PCDDs/PCDFs

- **By-products of various activities**
  - **Production of bleached paper by pulp and paper mills**
  - **Individual, municipal, industrial, and hazardous waste incineration**
  - **Wood burning stoves and fireplaces**

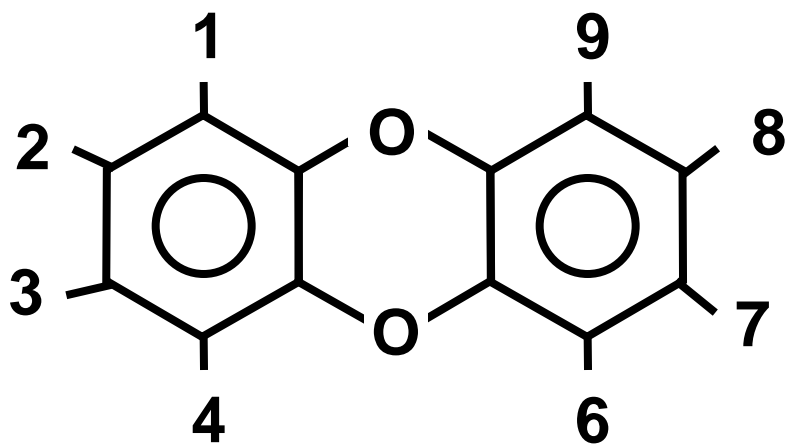


# PCDDs/PCDFs

- Petroleum refining
- Synthesis of certain chlorinated chemicals (pentachlorophenol, hexachlorophene, chlorinated phenoxy herbicides, PCBs, chlorinated benzenes)

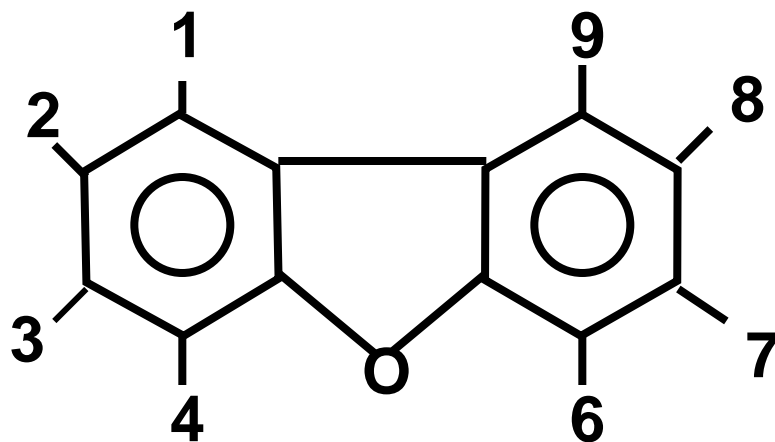


# PCDDs



**75 Congeners**

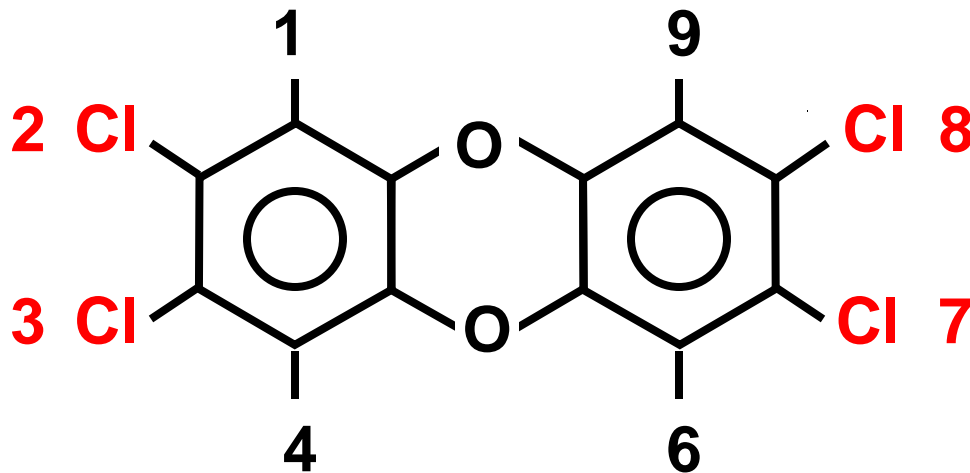
# PCDFs



**135 Congeners**

# Relationship Between PCDDs, PCBs and PCDFs

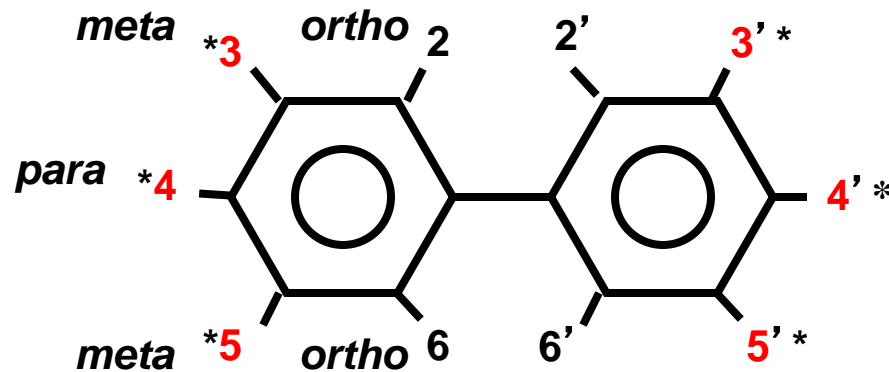
- TCDD most toxic based on LD<sub>50</sub> in guinea pigs



2,3,7,8-Tetrachlorodibenzo-*p*-dioxin (TCDD)

# Relationship Between PCDDs, PCBs and PCDFs

- Of the 209 PCB congeners, the most toxic are the non-*ortho*, coplanar congeners





# Relationship Between PCDDs, PCBs and PCDFs

- Four important *non-ortho* PCB congeners
  - 3,3' 4,4' -tetrachlorobiphenyl (PCB 77)
  - 3,4,5,4' -tetrachlorobiphenyl (PCB 81)
  - **3,3' 4,4' ,5-pentachlorobiphenyl (PCB 126)**
  - 3,3' 4,4' ,5,5' -hexachlorobiphenyl (PCB 169)

# **Relationship Between PCDDs, PCBs, and PCDFs**

- **Mono-ortho PCB congeners: 1 chlorine in the ortho (2, 6, 2', 6' ) position**
  - **Less toxic than the non-ortho, coplanar PCB congeners**
  - **8 mono-ortho TCDD-like PCB congeners**
- **7 TCDD-like PCDDs**
- **10 TCDD-like PCDFs**

# **Relationship Between PCDDs, PCBs and PCDFs**

- **TCDD-like chemicals have same mechanism of action as TCDD**
  - **TCDD binds to aryl hydrocarbon (*Ah*) receptor to induce characteristic effects**
  - **TCDD-like PCBs, PCDDs and PCDFs also bind to Ah receptor and elicit similar effects, although with less potency**

# **The Toxic Equivalency Approach**

- **Because these TCDD-like chemicals act via a common mechanism, the toxic equivalency approach can be used**
- **The toxicity of individual PCDD, PCB and PCDF congeners is assessed based on evaluation of data from in vitro and in vivo studies, leading to determination of TCDD-toxic equivalent factors (TEFs)**
- **These TEFs are order-of-magnitude consensus estimates of TCDD-like toxicity**

# The Toxic Equivalency Approach

- TEFs are used to weigh measured concentrations of the congeners present in a sample in relation to TCDD, which is assigned a TEF of 1
- Product of measured concentration of each congener and TEF weighing factor = concentration of TCDD-toxic equivalents (TEQs) contributed by that congener
- The total TCDD-like toxicity associated with the sample is the sum of the TEQs contributed by each TCDD-like congener

# TEFs of PCDD Congeners

- **2,3,7,8-TCDD**  
**1.0**
- **1,2,3,7,8-PeCDD**  
**1.0**
- **1,2,3,4,7,8-HxCDD**  
**0.1**
- **1,2,3,6,7,8-HxCDD**  
**0.1**
- **1,2,3,7,8,9-HxCDD**  
**0.1**
- **1,2,3,4,6,7,8-HpCDD**  
**0.01**
- **OCDD**  
**0.0003**

# TEFs of PCDF Congeners

- 2,3,7,8-TCDF  
0.1
- 1,2,3,7,8-PeCDF  
0.03
- 2,3,4,7,8-PeCDF  
0.3
- 1,2,3,4,7,8-HxCDF  
0.1
- 1,2,3,6,7,8-HxCDF  
0.1
- 1,2,3,7,8,9-HxCDF  
0.1
- 2,3,4,6,7,8-HxCDF  
0.1
- 1,2,3,4,6,7,8-HpCDF  
0.01
- 1,2,3,4,7,8,9-HpCDF  
0.01
- OCDF  
0.0003

# TEFs of Non-*ortho* PCB Congeners

▪ PCB 77	0.0001
▪ PCB 81	0.0003
▪ <b>PCB 126</b>	<b>0.1</b>
▪ PCB 169	0.03



# TEFs of Mono-ortho PCB Congeners

- |                      |                      |
|----------------------|----------------------|
| ▪ PCB 105<br>0.00003 | • PCB 156<br>0.00003 |
| ▪ PCB 114<br>0.00003 | • PCB 157<br>0.00003 |
| ▪ PCB 118<br>0.00003 | • PCB 167<br>0.00003 |
| ▪ PCB 123<br>0.00003 | • PCB 189<br>0.00003 |

# TCDD-TEQs in Lake Wobegon Fish

Congener	[ ] in fish (pg/g)	TEF	TEQs (pg/g)
<b>PCB 126</b>	<b>410</b>	<b>0.1</b>	<b>41.0 (88%)</b>
<b>PCB 169</b>	<b>105</b>	<b>0.03</b>	<b>3.2 (6.8%)</b>
<b>PCB 156</b>	<b>23,000</b>	<b>0.00003</b>	<b>0.7 (1.5%)</b>
<b>TCDD</b>	<b>0.5</b>	<b>1.0</b>	<b>0.5 (1.1%)</b>
<b>2,3,4,7,8- PeCDF</b>	<b>4.6</b>	<b>0.3</b>	<b>1.4 (3.0%)</b>
<b>Total TEQs</b>			<b>46.8</b>

# Why Mink?



# Why Mink?

- Mink (*Neovision vison*) used as a representative species to study effects of TCDD-like chemicals on piscivorous mammals



# Why Mink?

- Exposed to high concentrations of TCDD-like compounds because of diet and position in the food chain
- Sensitive to TCDD-like chemicals
- Can be used in controlled exposure situations

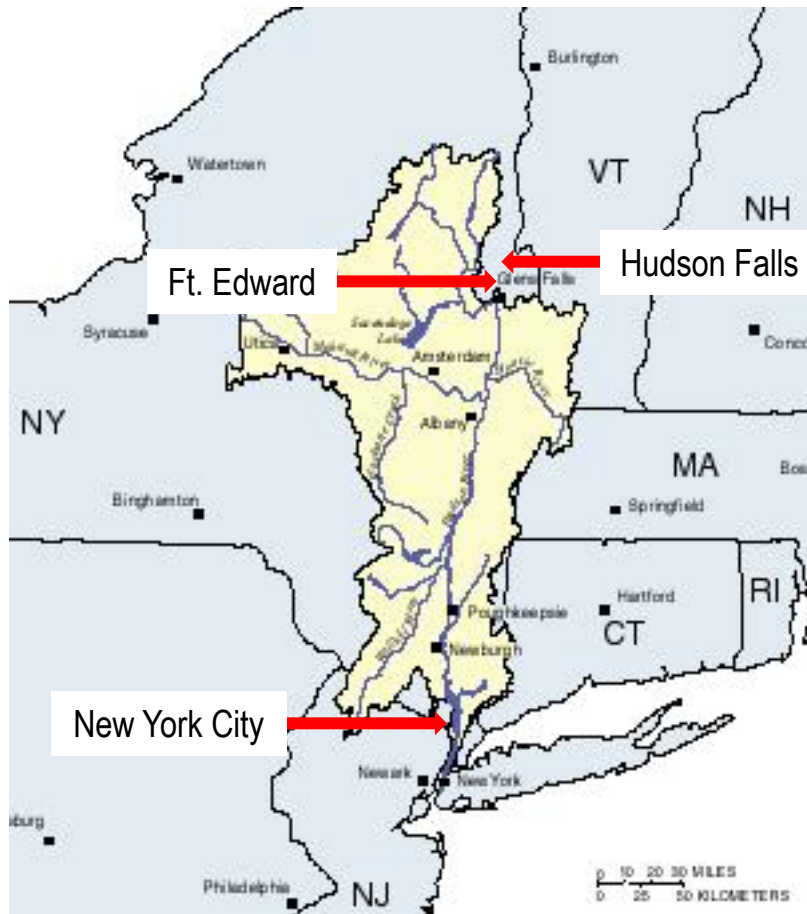




# Hudson River Study



# Introduction



- **Hudson River**
  - **Contaminated with PCBs from Ft. Edward to New York City**
- **Major sources of PCBs**
  - **Manufacturing facilities at Ft. Edward and Hudson Falls**

# Introduction

- **Field studies over past 30 years**
  - **Evidence that wild mink have hepatic PCB concentrations suggesting risk of reproductive impairment**
  - **Concentrations have not decreased appreciably**





# Introduction

- **Mink collected from PCB-contaminated sections of the Hudson River between Fort Edward and Troy between 1998 and 2001**
  - **Hepatic  $\Sigma$ PCBs concentrations**
    - **Within 6 km (1 home range) = 13  $\mu\text{g/g}$  lipid (0.54 - 139)**
    - **Within 1 km of river = 33  $\mu\text{g/g}$  lipid (1.4 - 139)**
  - **LOAECs for reduced kit survival**
    - **45  $\mu\text{g/g}$  lipid (Heaton et al.1995; Saginaw Bay)**
    - **29  $\mu\text{g/g}$  lipid (Bursian et al. 2006; Housatonic River)**

# Objective

- To evaluate health effects of feeding ranch mink diets containing PCB-contaminated fish from the Hudson River
  - Reproductive performance
  - Offspring survival
  - Organ mass and tissue pathology



# Methods

- **Carp collected from 3 locations on upper Hudson River between Fort Edward and just south of Mechanicville**
  - **Moses Kill**
  - **Northumberland Pool**
  - **Lock 2 vicinity**













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# Methods



- **Ground fish (ocean herring and/or HR carp) incorporated into feed at a rate of 20%**





# Dietary Concentrations of $\Sigma$ PCBs and TEQs

<b>Ocean herring</b> (0.09 $\mu\text{g } \Sigma\text{PCBs/g, ww}$ )	<b>20%</b>	<b>17.5%</b>	<b>15%</b>	<b>10%</b>	<b>5%</b>	<b>0%</b>
<b>Hudson River carp</b> (36 $\mu\text{g } \Sigma\text{PCBs/g, ww}$ )	<b>0%</b>	<b>2.5%</b>	<b>5%</b>	<b>10%</b>	<b>15%</b>	<b>20%</b>
<b>Targeted dietary concentrations</b> ( $\mu\text{g } \Sigma\text{PCBs/g feed}$ )	<b>0</b>	<b>0.90</b>	<b>1.8</b>	<b>3.6</b>	<b>5.4</b>	<b>7.2</b>
<b>Analyzed dietary concentrations</b> ( $\mu\text{g } \Sigma\text{PCBs/g feed}$ )	<b>0.007</b>	<b>0.72</b>	<b>1.5</b>	<b>2.8</b>	<b>4.5</b>	<b>6.1</b>
<b>Total TEQs</b> (pg TEQs/g feed)	<b>0.72</b>	<b>5.4</b>	<b>10</b>	<b>20</b>	<b>28</b>	<b>38</b>

# Contribution to TEQs

- PCDDs = 1.5%
- PCDFs = 1.4%
- PCBs = 97%
  - Non-*ortho* PCBs = 75%
    - PCB 126 = 75%
  - Mono-*ortho* PCBs = 22%

# Number of Female and Male Mink per Treatment Group

	$\mu\text{g } \Sigma\text{PCBs/g feed}$					
	Control	0.72	1.5	2.8	4.5	6.1
# Females	15	10	10	10	15	15
# Males	5	5	5	5	5	5

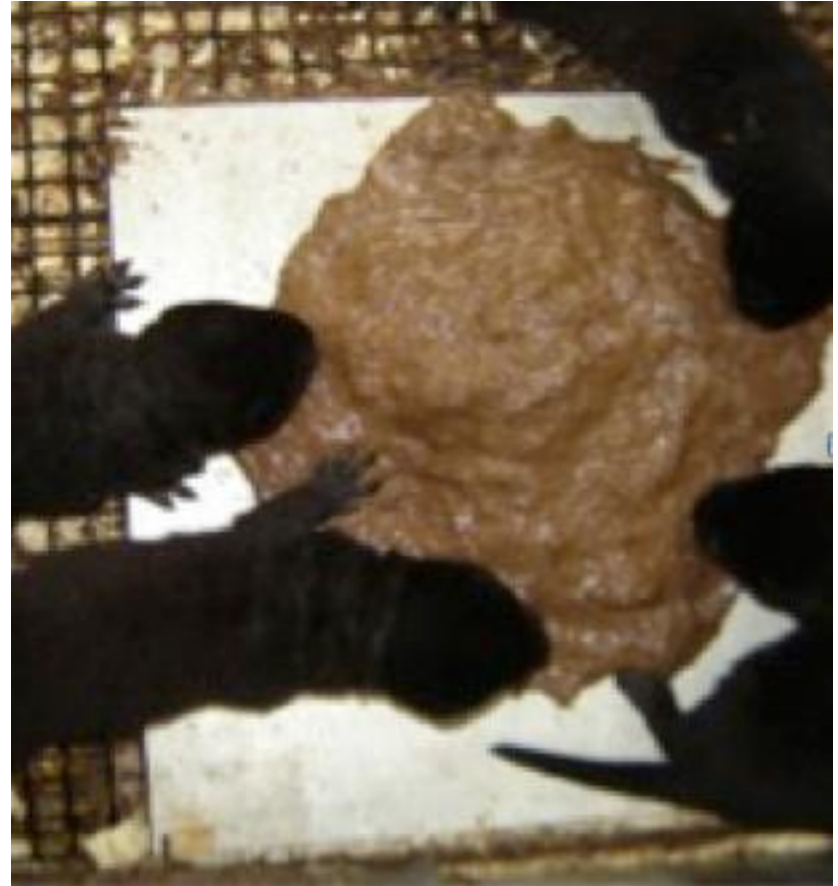
# Methods

- **Animals housed singly in open-sided pole barn**
- **Test diets fed from 8 weeks prior to breeding (first 3 wks of March) through weaning of kits (mid-June)  $\approx$  160 days**
- **Kits weighed at 24 hr post-partum and at 3 and 6 wk of age**



# Methods

- Adults and sample of kits necropsied when kits were  $\approx$  6 wk old
- Liver, brain, heart, kidneys, spleen, thyroid gland, adrenal glands, testes/uterus, mandible/maxilla removed, weighed, fixed for histology
- Portion of liver frozen for contaminant analysis





# Methods

## ◆ Remaining kits maintained on dietary treatment until ~ 31 wk old

- Control - 47 kits
- 0.72  $\mu\text{g}$   $\Sigma\text{PCBs/g}$  - 24 kits
- 1.5  $\mu\text{g}$   $\Sigma\text{PCBs/g}$  - 13 kits
- 2.8  $\mu\text{g}$   $\Sigma\text{PCBs/g}$  - 9 kits
- 4.5  $\mu\text{g}$   $\Sigma\text{PCBs/g}$  - 12 kits
- 6.1  $\mu\text{g}$   $\Sigma\text{PCBs/g}$  - 2 kits

## ◆ Necropsied juveniles (30 controls and 23 in 0.72 $\mu\text{g}$ $\Sigma\text{PCBs/g}$ feed group)



# Summary of Study Endpoints, Data Types and Statistical Analysis Methods

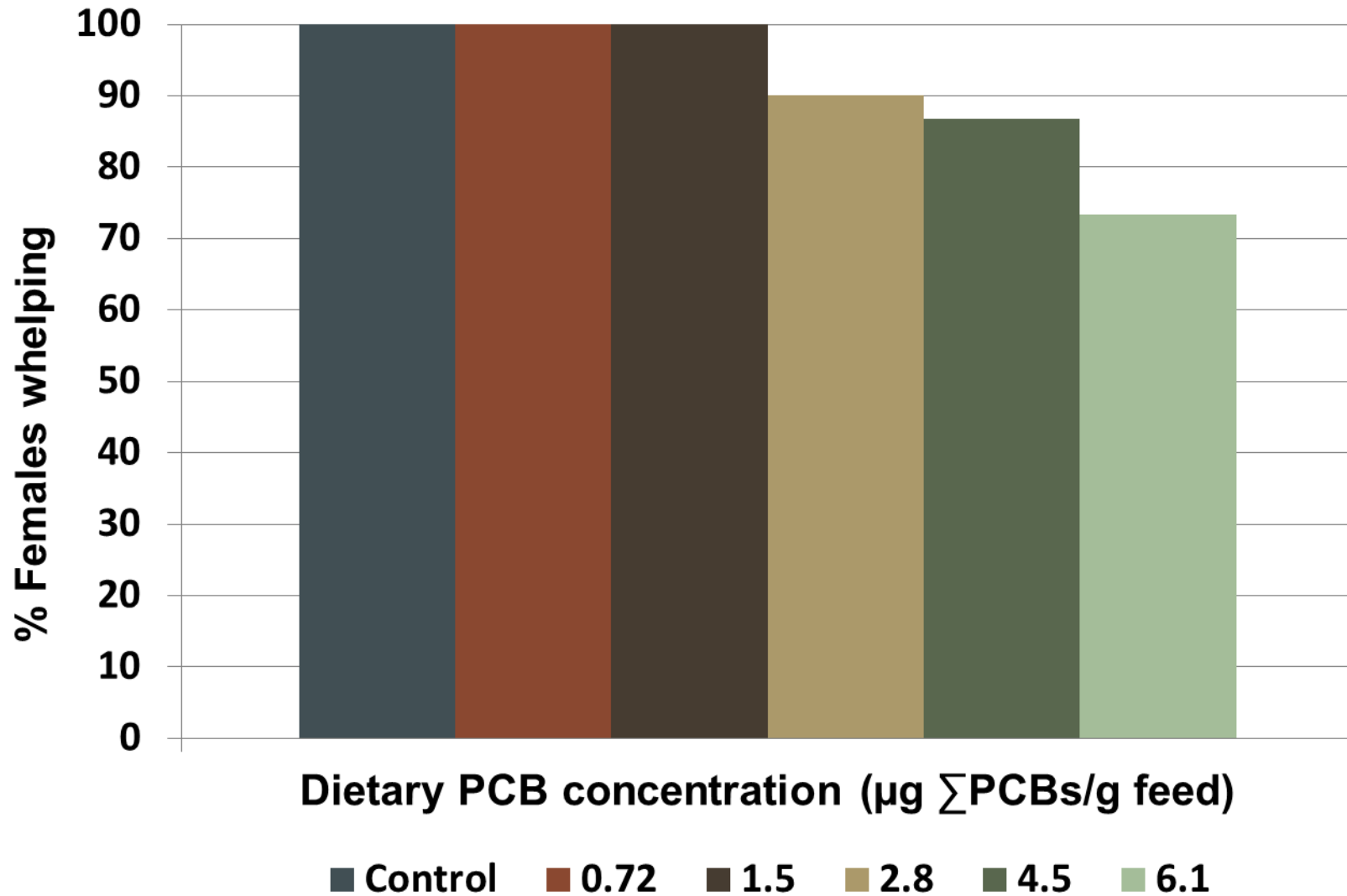
Endpoint	Data Type	Statistical Methods
Adult body weight	Continuous	Generalized Estimating Equations Regression for Repeated Measures
Adult feed consumption	Continuous	Generalized Estimating Equations Regression for Repeated Measures
Number of females mated	Binary	Logistic Regression / Fisher's Exact Test
Length of gestation	Continuous	ANOVA / Linear Regression
Number of females whelping	Binary	Logistic Regression / Fisher's Exact Test
Number whelped per female	Count	Negative Binomial Regression
Number whelped live per female	Count	Negative Binomial Regression
Average litter weight	Continuous	ANOVA / Linear Regression
Kit weight at birth, three and six weeks	Continuous	Linear Generalized Estimating Equation Regression
Kit mortality at three and six weeks	Binary	Beta-Binomial Regression
Monthly body weights of seven-month-old juveniles	Continuous	Linear Generalized Estimating Equation Regression



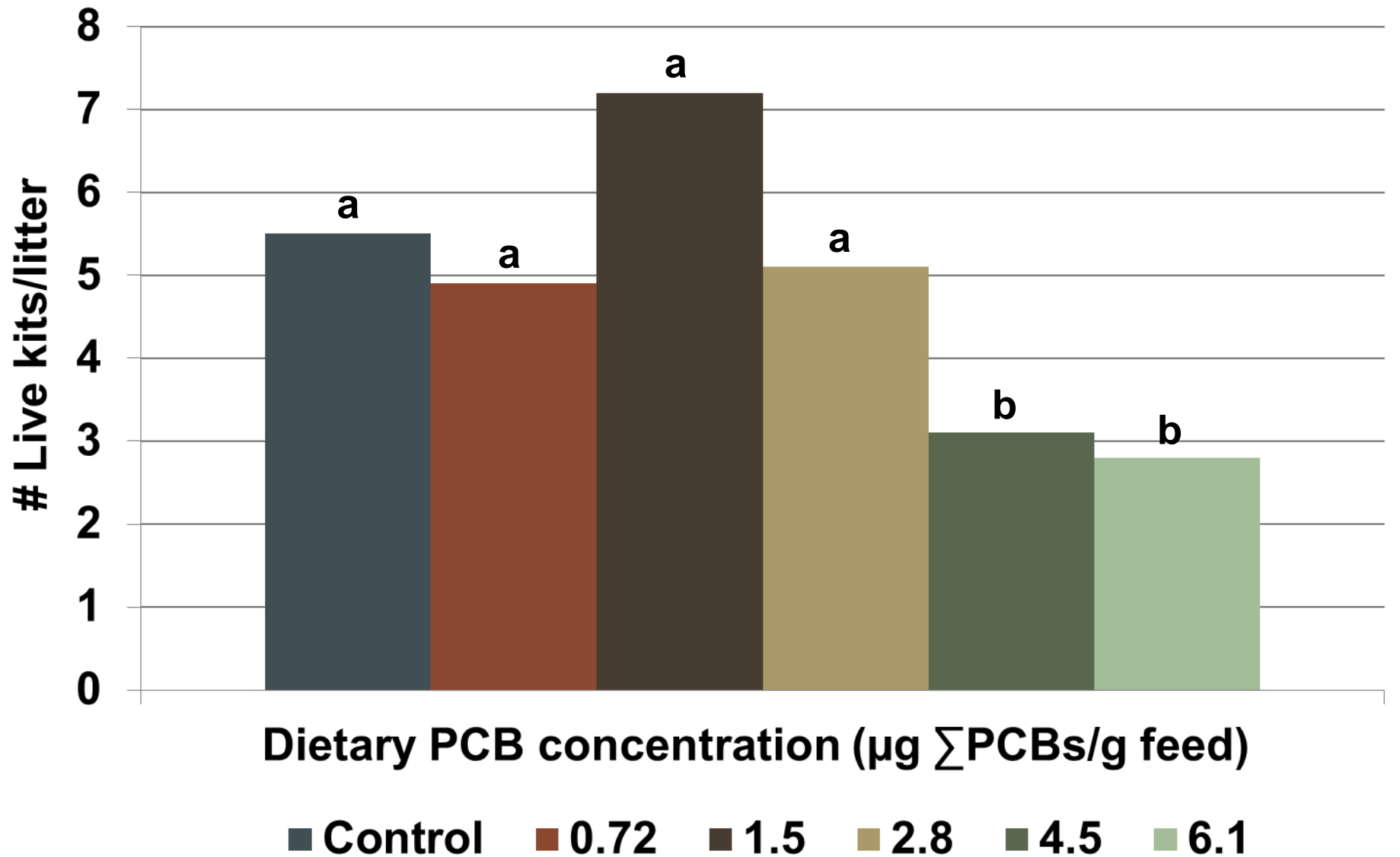
# Summary of Study Endpoints, Data Types and Statistical Analysis Methods

Adult organ weights	Continuous	ANOVA / Linear Regression		
Six-week-old kit organ weight	Continuous	Linear Equation	Generalized Regression	Estimating
Seven-month-old juvenile organ weight	Continuous	Linear Equation	Generalized Regression	Estimating
Total PCB and Total TEQs in adult livers	Continuous	ANOVA / Linear Regression		
Total PCB and Total TEQs in six-week-old kit livers	Continuous	Linear Equation	Generalized Regression	Estimating
Total PCB and Total TEQs in seven-month-old juveniles livers	Continuous	Linear Equation	Generalized Regression	Estimating
Histopathology of adult organs and jaws	Binary	Logistic / Fisher's Exact Test		
Histopathology of six-week-old kit organs and jaws	Binary	Beta-Binomial Regression / Fisher's Exact Test		
Histopathology of seven-month-old juvenile organ and jaws	Binary	Beta-Binomial Regression / Fisher's Exact Test		

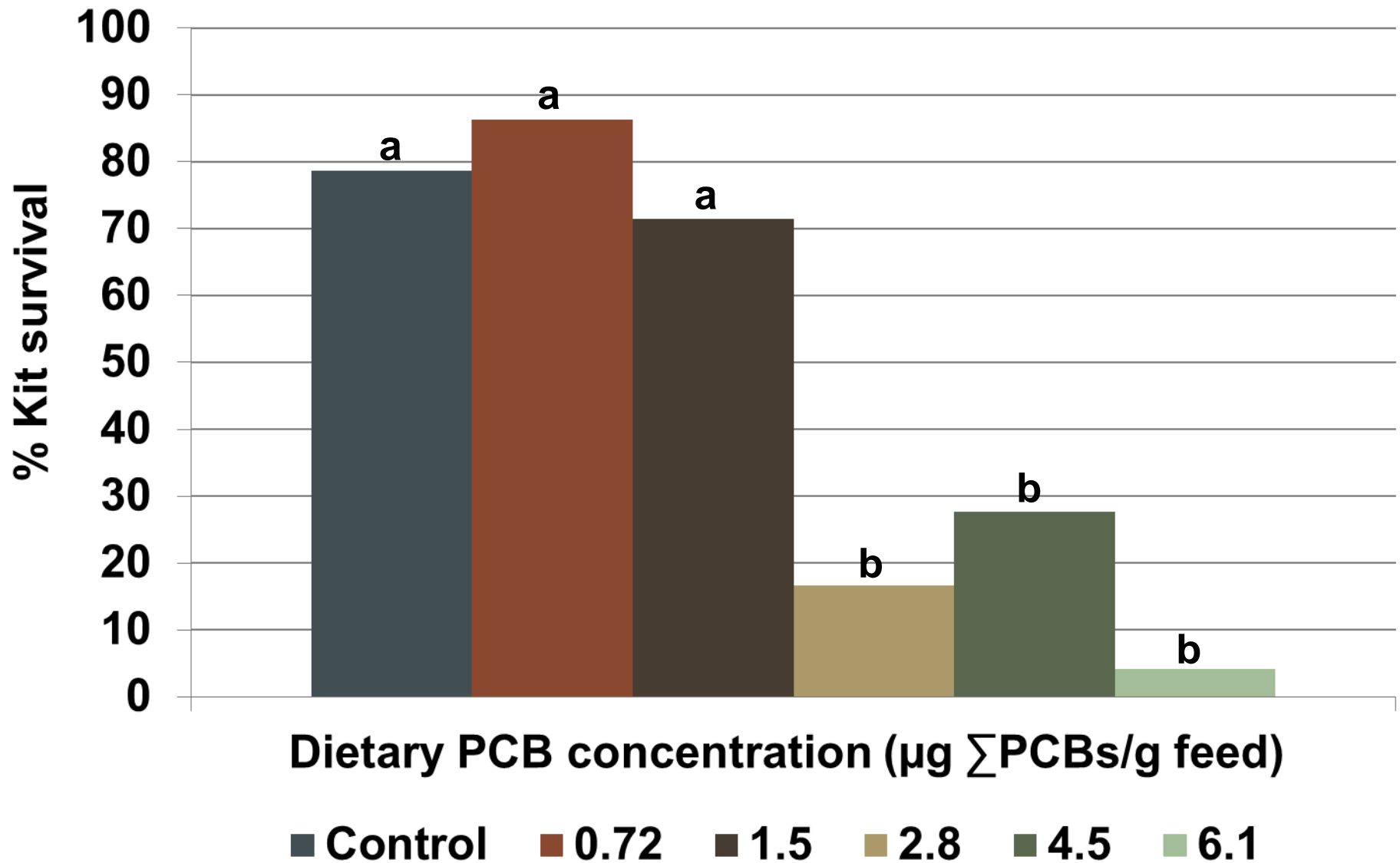
# Percent of Females Whelping



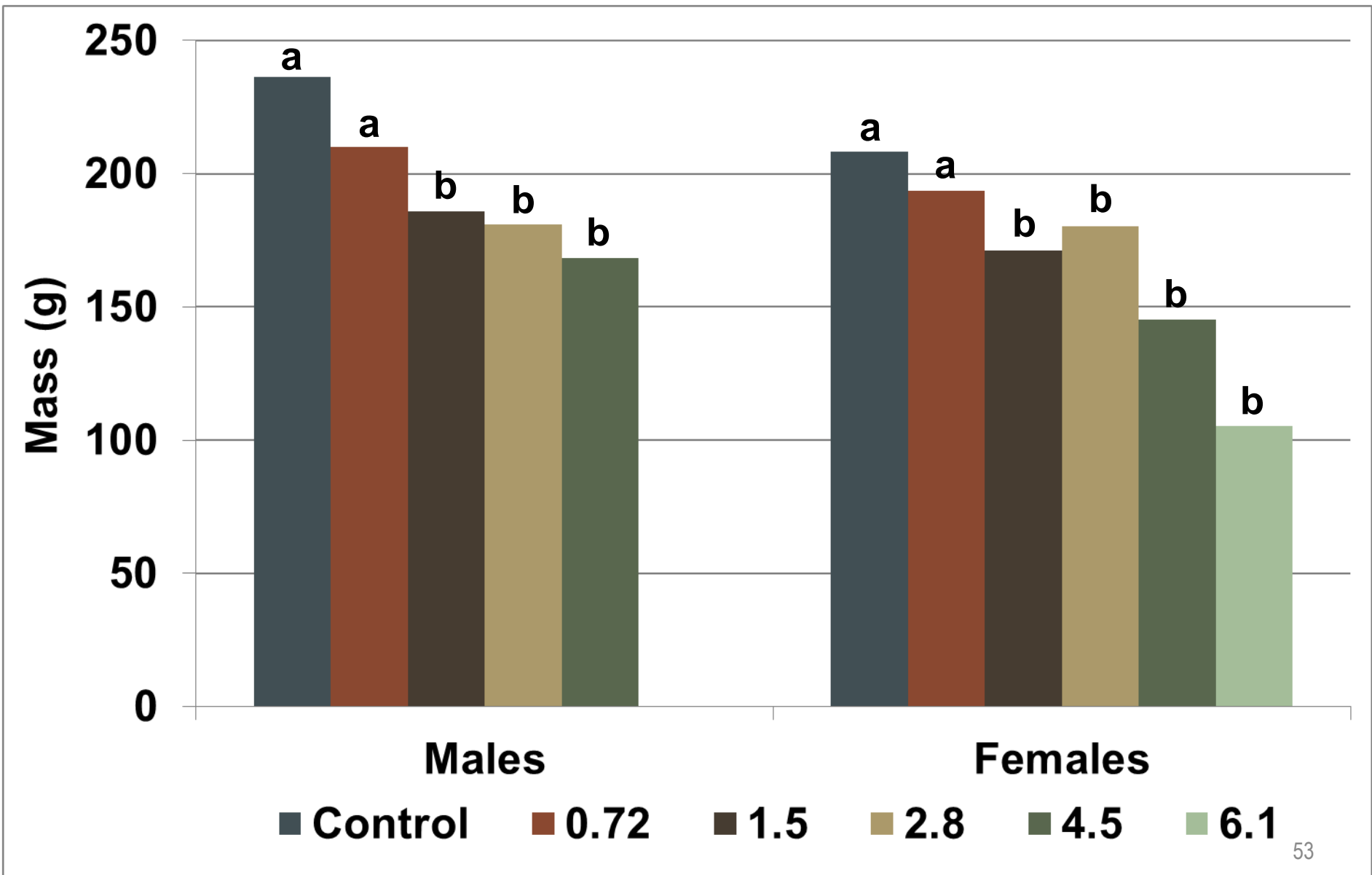
# Live Kits Per Litter



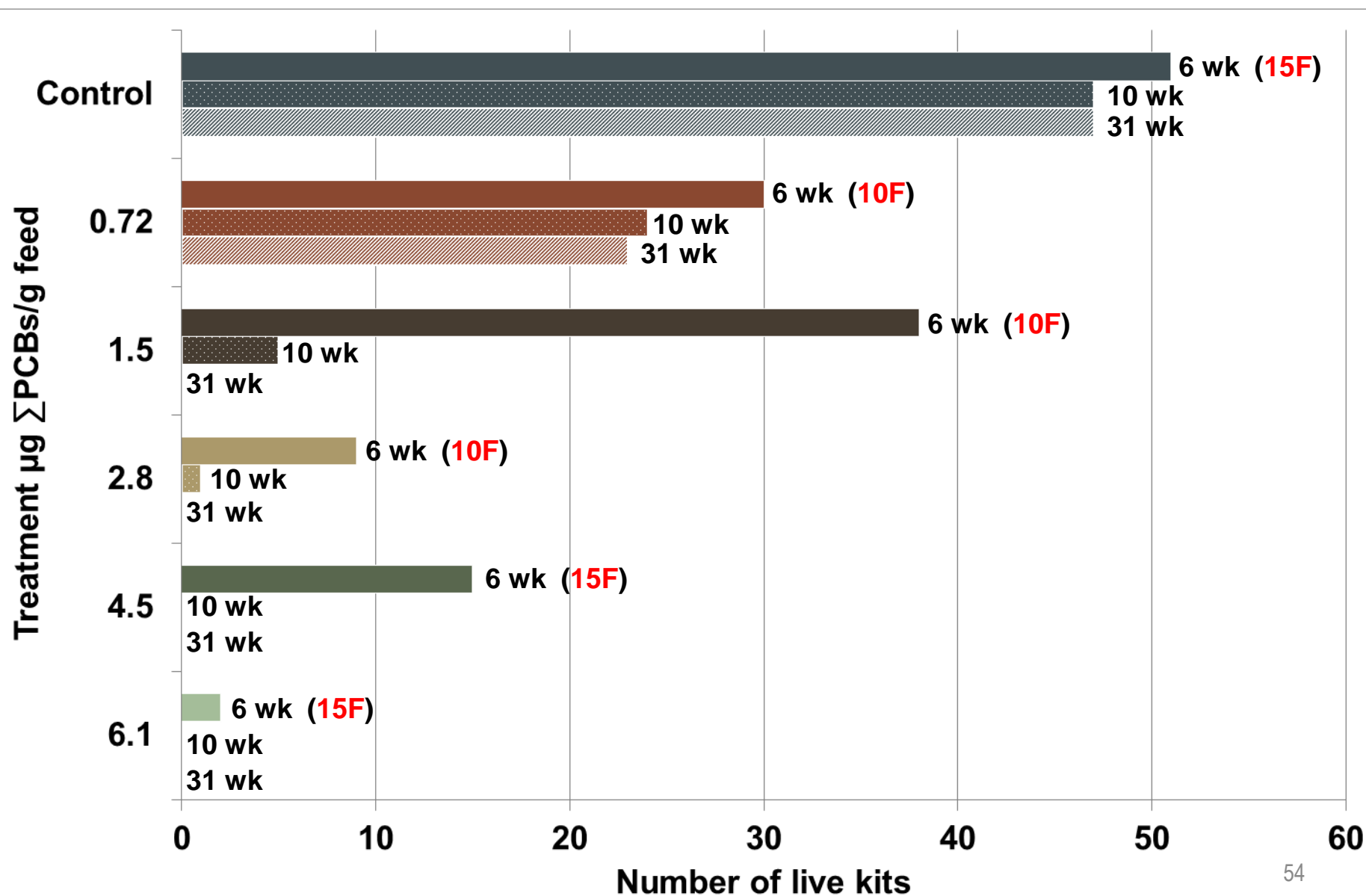
# Percent Survival of 6-wk-old Kits



# Mass of 6-wk-old Kits



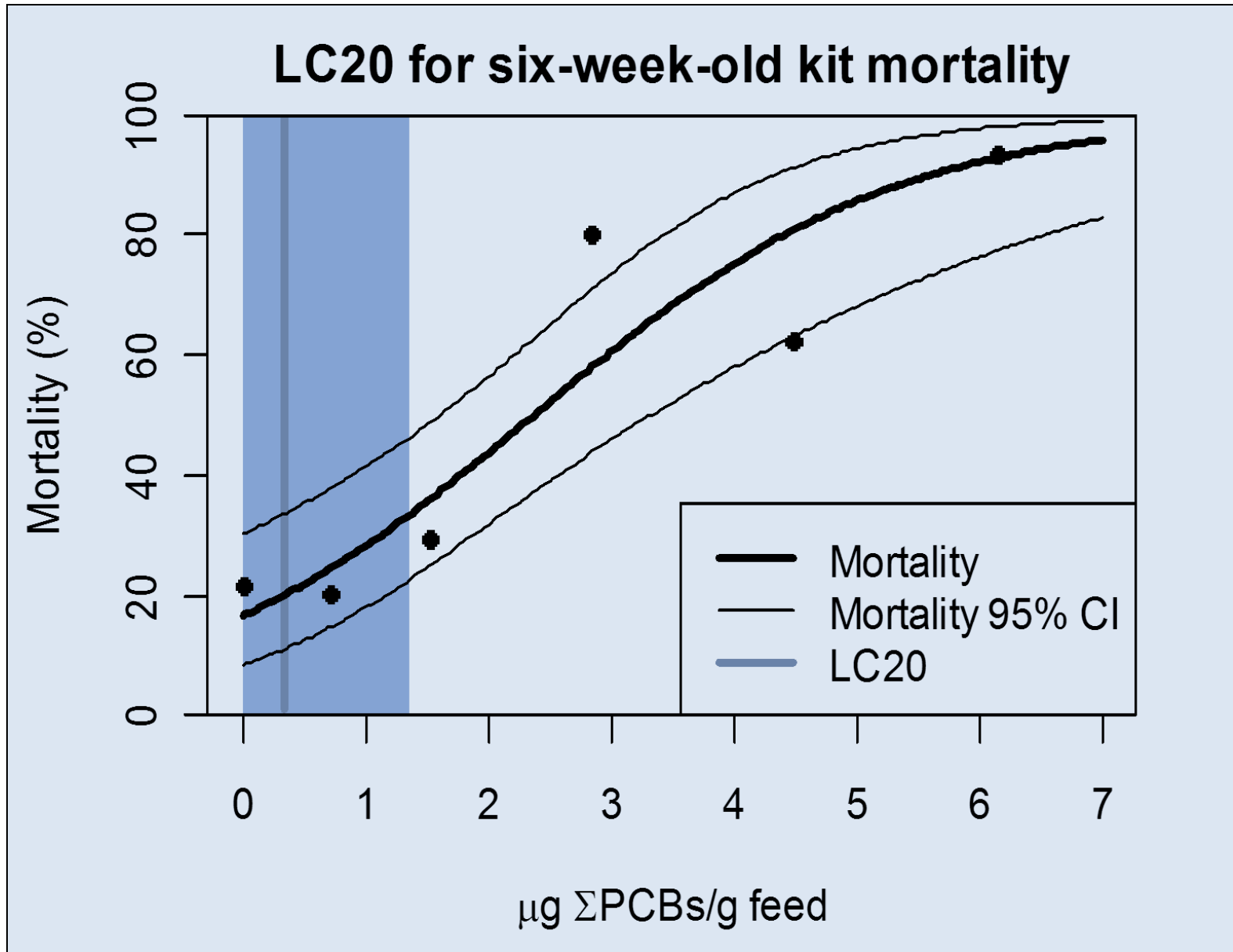
# Offspring Mortality Between 6 and 31 Wk of Age



# Dietary and Maternal Hepatic Concentrations of $\Sigma$ PCBs and TEQs

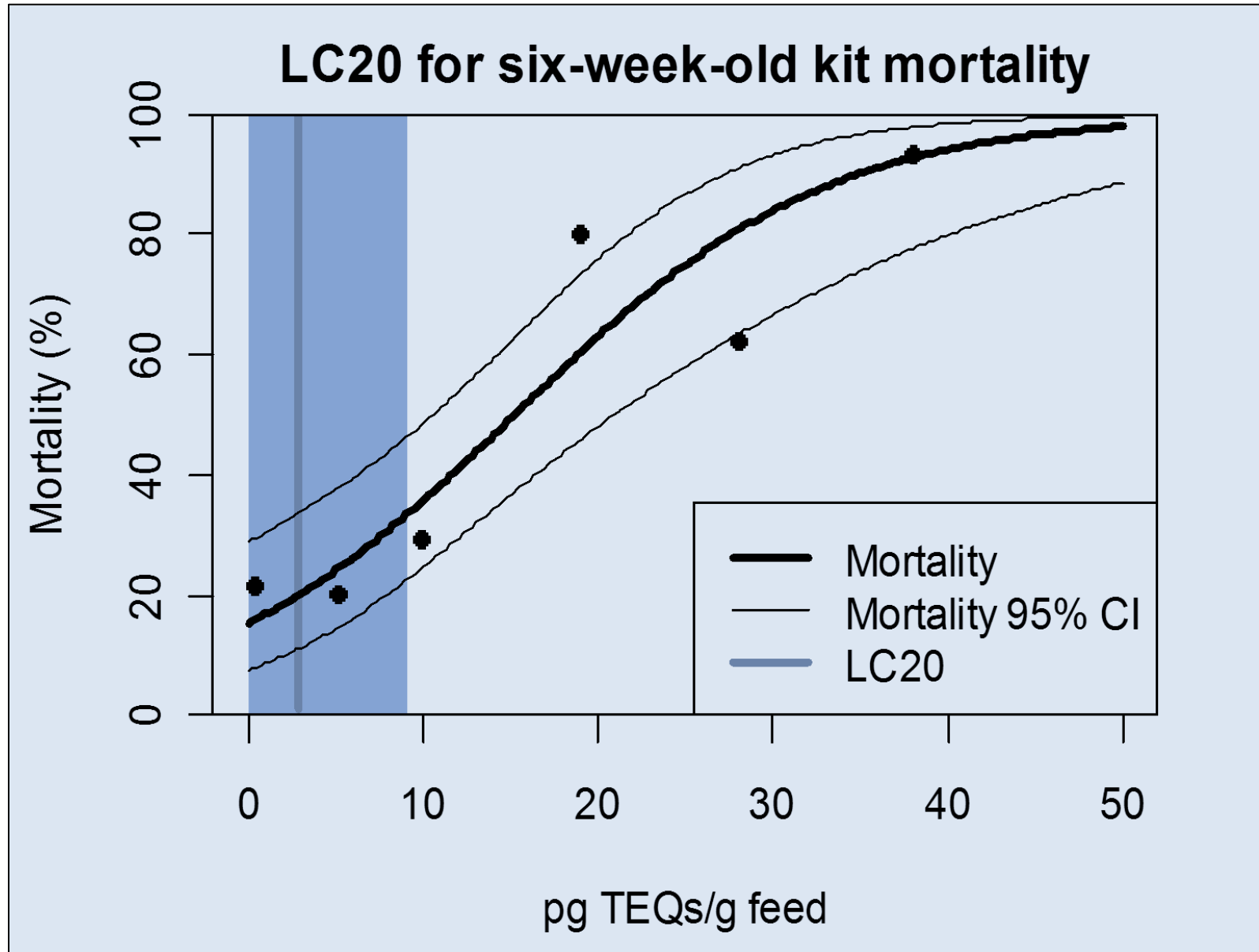
<b>Dietary PCBs</b> ( $\mu\text{g } \Sigma\text{PCBs/g feed}$ )	<b>0.007</b>	<b>0.72</b>	<b>1.5</b>	<b>2.8</b>	<b>4.5</b>	<b>6.1</b>
<b>Dietary TEQs</b> (pg TEQs/g feed)	<b>0.72</b>	<b>5.4</b>	<b>10</b>	<b>20</b>	<b>28</b>	<b>38</b>
<b>Hepatic PCBs</b> ( $\mu\text{g } \Sigma\text{PCBs/g liver}$ )	<b>0.051</b>	<b>1.4</b>	<b>2.8</b>	<b>3.3</b>	<b>4.9</b>	<b>6.2</b>
<b>Hepatic TEQs</b> (pg TEQs/g liver)	<b>2.4</b>	<b>33</b>	<b>61</b>	<b>101</b>	<b>181</b>	<b>220</b>

# Dietary $\Sigma$ PCBs/TEQs Associated with 20% Mortality of 6-wk-old Kits

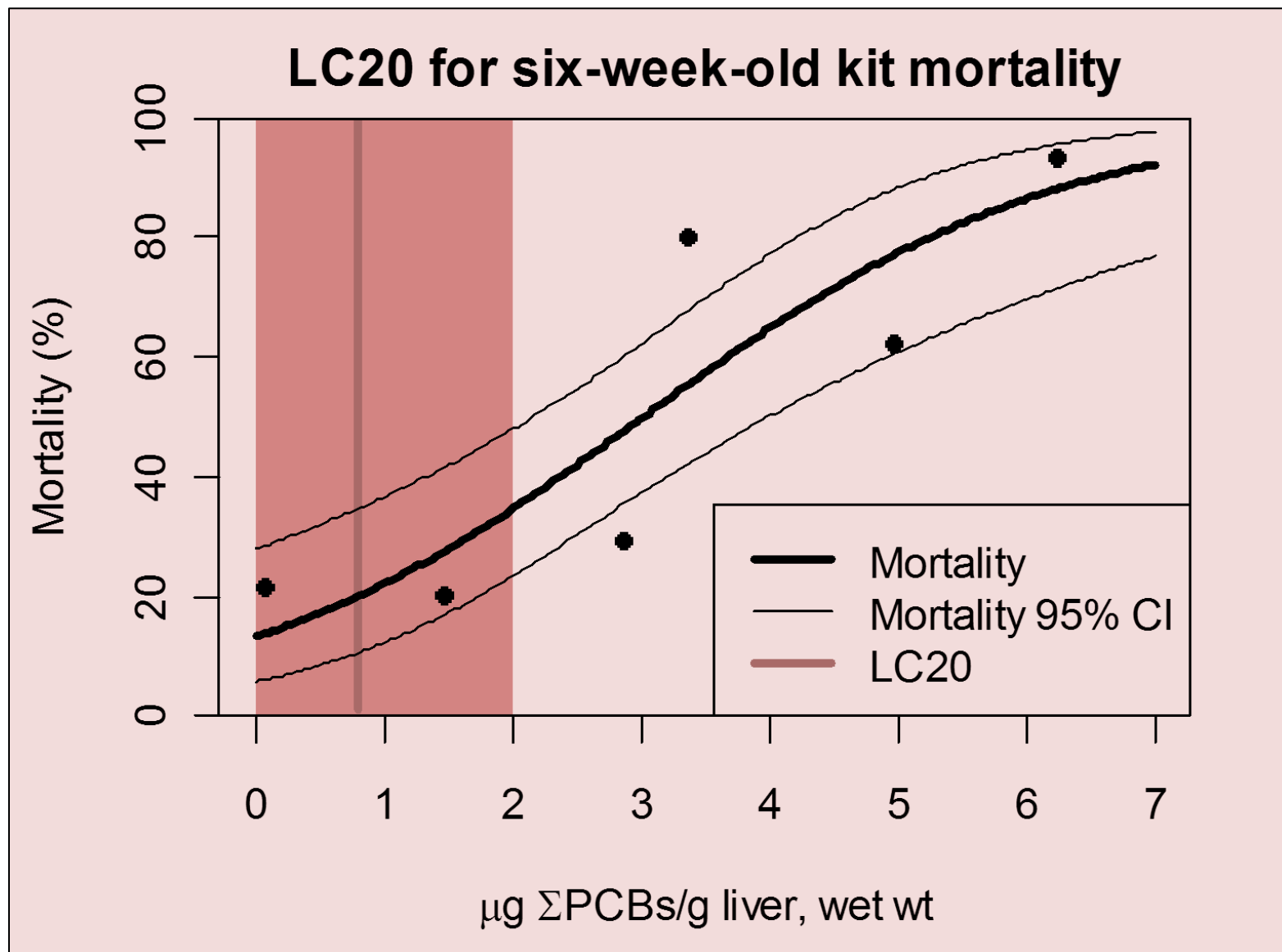




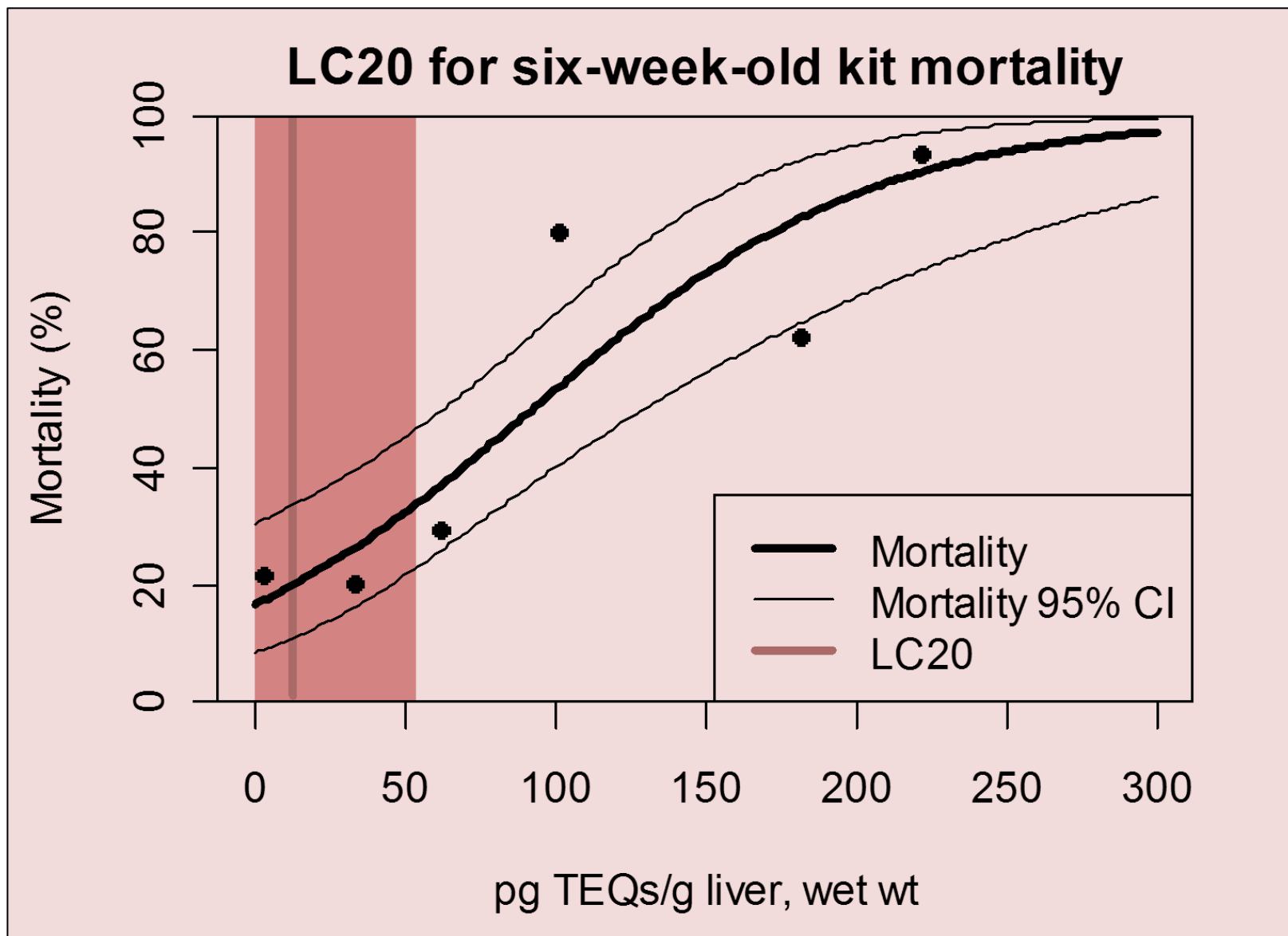
# Dietary TEQs Associated with 20% Mortality of 6-wk-old Kits



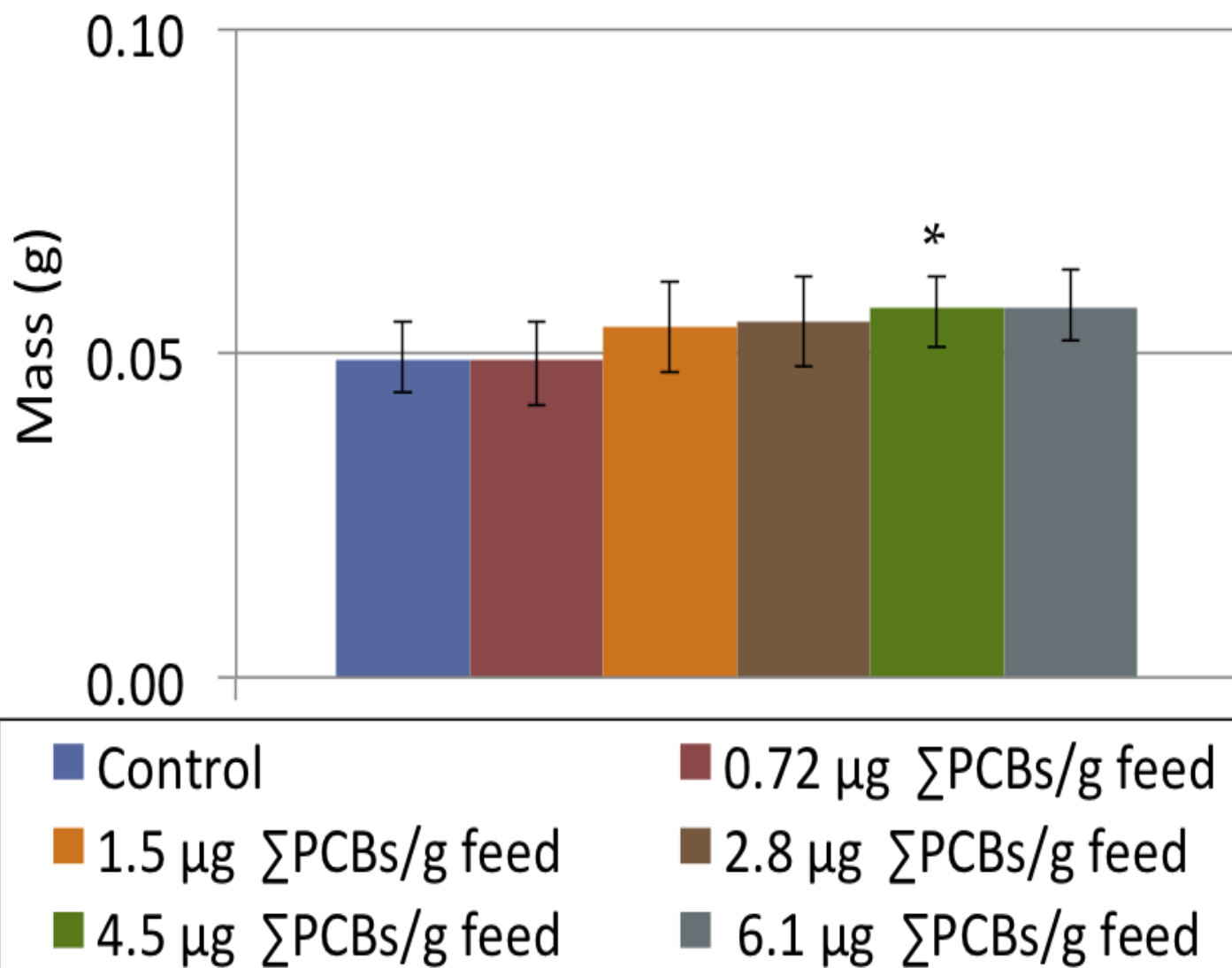
# Hepatic $\Sigma$ PCBs Associated with 20% Mortality of 6-wk-old Kits



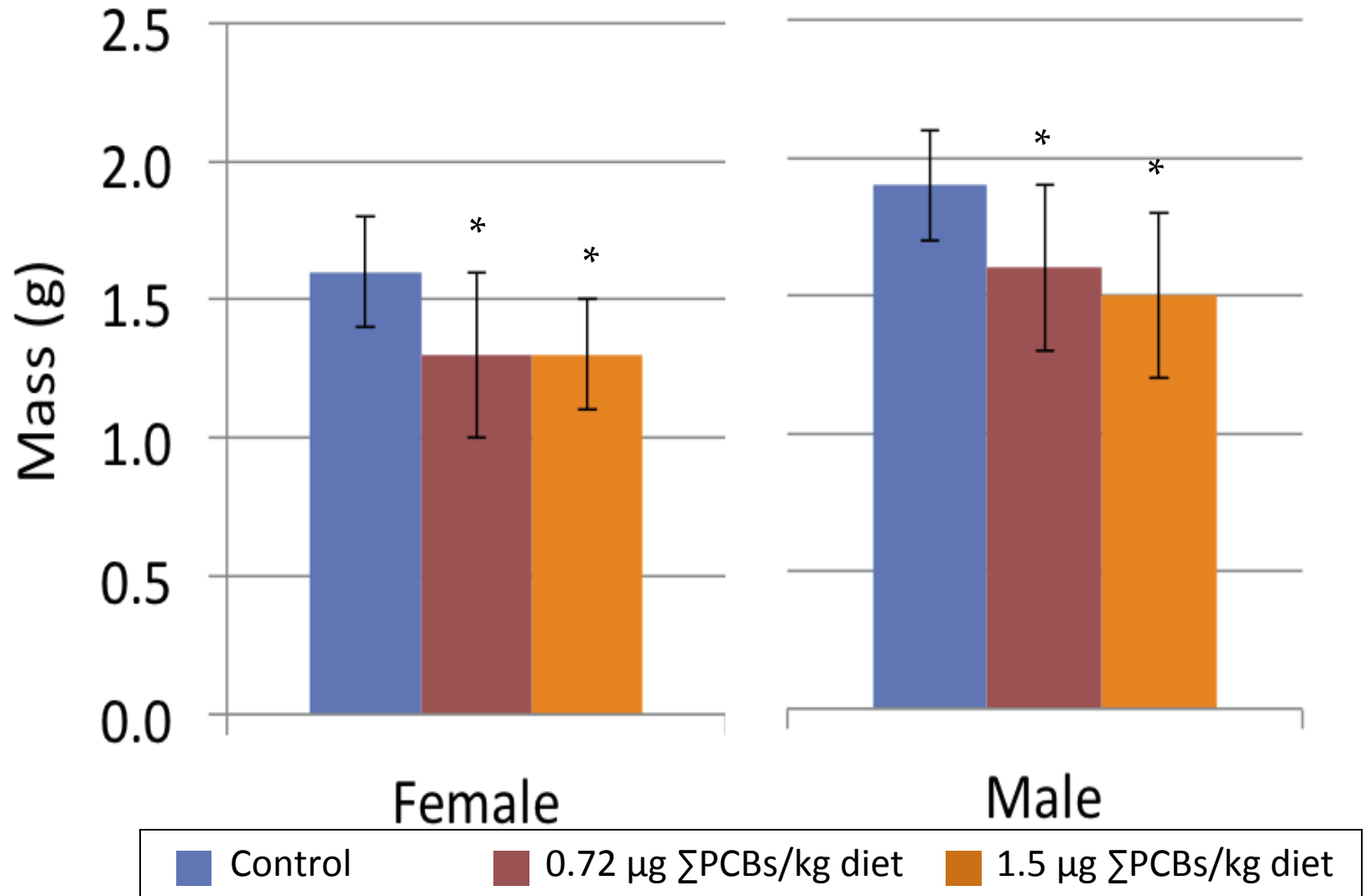
# Hepatic TEQs Associated with 20% Mortality of 6-wk-old Kits



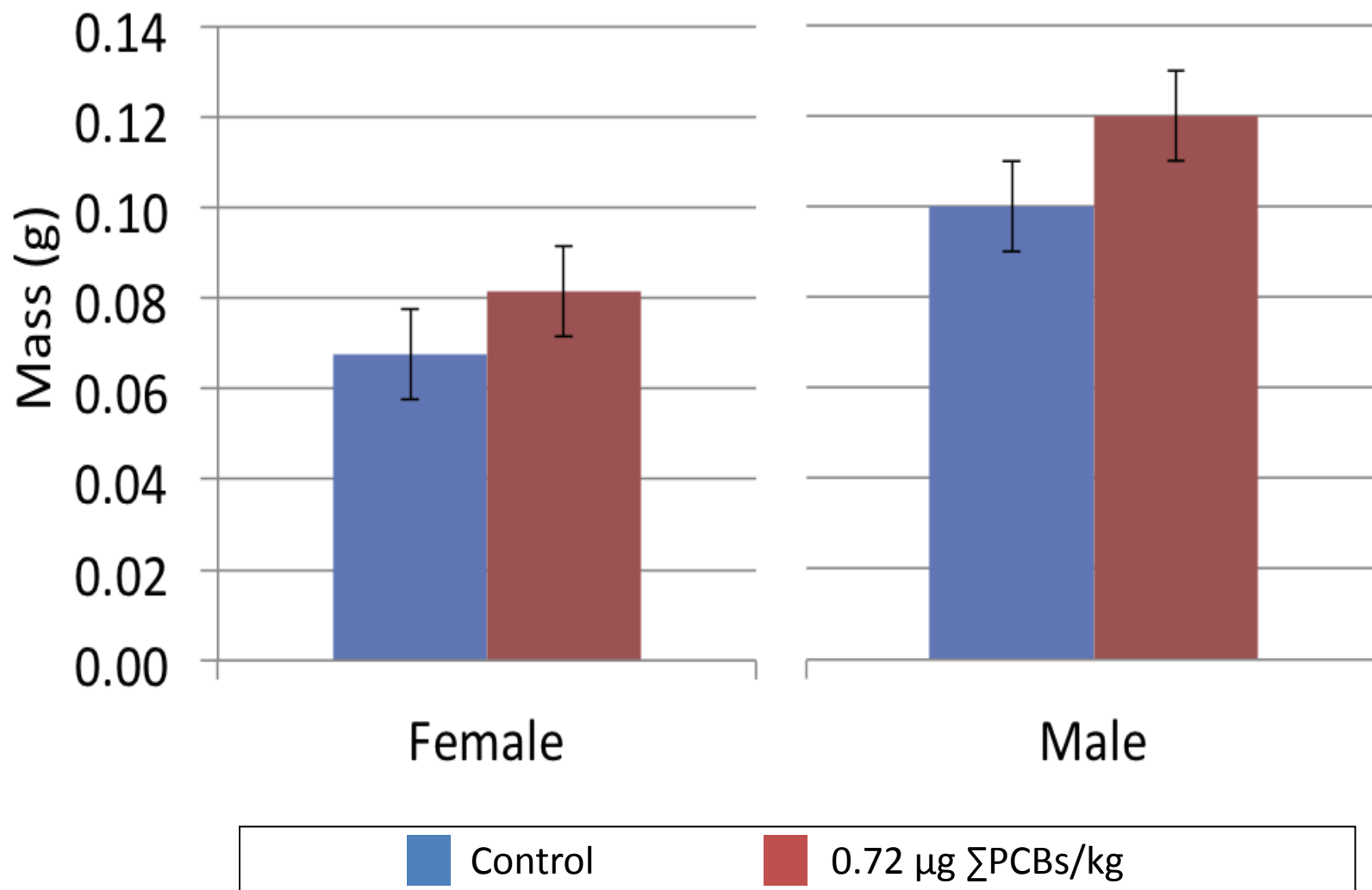
## Effect of feeding Hudson River fish on adult female mink thyroid mass



# Effect of Feeding Hudson River Fish on 6-wk-old Mink Kit Heart Mass



## Effect of Feeding Hudson River Fish on 31-wk-old Juvenile Mink Adrenal Gland Mass



# Effective Concentrations of $\Sigma$ PCBs and TEQs in Feed and Liver Producing Jaw Lesions in 20% and 50% of Adult Mink (EC20, EC50)

		EC20	95% Confidence Interval	EC50	95% Confidence Interval
<b>Feed</b>	$\mu\text{g } \Sigma\text{PCBs/g feed}$	2.3	1.5 – 3.1	3.9	3.2 - 4.6
	$\text{pg TEQs/g feed}$	15	10 - 20	25	21 - 29
<b>Liver</b>	$\mu\text{g } \Sigma\text{PCBs/g liver}$	2.8	2.1 – 3.6	4.4	3.7 - 5.1
	$\text{pg TEQs/g liver}$	89	58 - 121	151	125 - 178





**Normal maxilla from a control adult female mink showing teeth (T) and peridontal ligament (PL).**

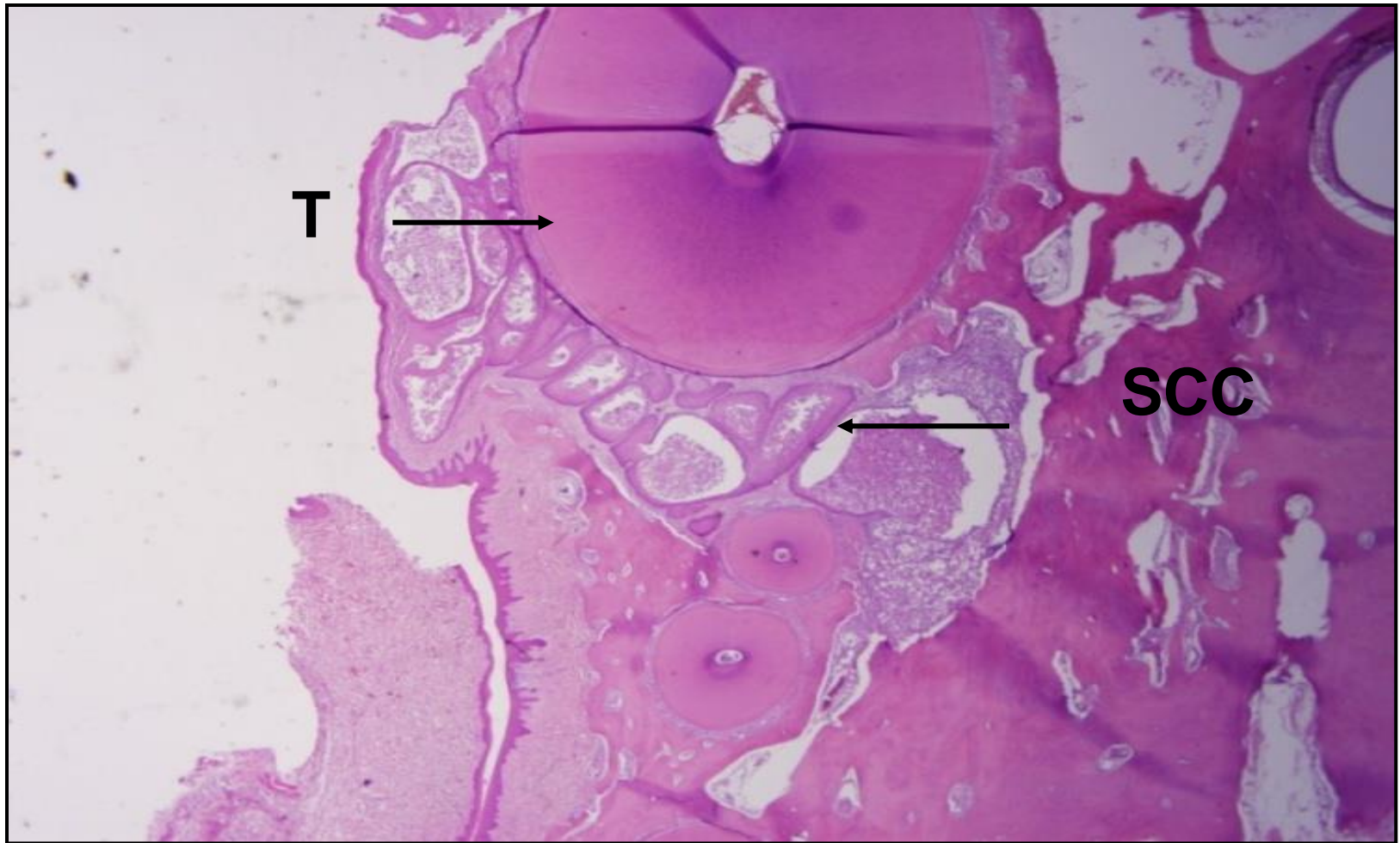


**Maxilla of a 4.5  $\mu\text{g}$   $\Sigma\text{PCBs/g}$  feed adult female mink showing mild squamous epithelial cell (SCC – squamous cell cyst) proliferation (one site).**



**Maxilla of a 4.5  $\mu\text{g}$   $\Sigma\text{PCBs/g}$  feed adult female mink showing moderate squamous epithelial cell proliferation at two sites.**





**Maxilla of a 6.1  $\mu\text{g}$   $\Sigma\text{PCBs/g}$  feed adult male showing severe squamous epithelial cell proliferation shown at multiple sites.**

# Displacement and Loss of Teeth



# Conclusions

- **Reproductive performance of adult female mink and offspring survival and growth were adversely affected by consumption of feed containing PCBs derived from fish collected from the Hudson River**

# Conclusions

- **Reproductive Performance**
  - # Stillborn kits/litter increased by dietary concentrations of 4.5  $\mu\text{g}$   $\Sigma\text{PCBs/g}$  feed (28 pg TEQs/g feed) and greater
- **Kit Survivability**
  - Dietary LC20 based on kit survivability at 6 wk of age = 0.34  $\mu\text{g}$   $\Sigma\text{PCBs/g}$  feed (2.9 pg TEQs/g feed)
  - Hepatic LC20 based on kit survivability at 6 wk of age = 0.80  $\mu\text{g}$   $\Sigma\text{PCBs/g}$  liver, ww (13 pg TEQs/g liver, ww)
- **Kit Growth**
  - Average body masses in the 1.5, 2.8 and 4.5  $\mu\text{g}$   $\Sigma\text{PCBs/g}$  feed groups (10, 19 and 28 TEQs/g feed, respectively) were less than controls at 6 wk of age



# Conclusions

- **Organ Mass**
  - **↑ thyroid mass of adult females, ↓ heart mass of 6-wk-old kits, ↑ adrenal gland mass of juvenile mink**
- **Tissue Histopathology**
  - **Development of a jaw lesion in adult mink characterized as mandibular and maxillary squamous epithelial proliferation**
    - **Dietary EC20 = 2.3  $\mu\text{g}$   $\Sigma\text{PCBs/g}$  (15 pg TEQs/g)**
    - **Dietary EC50 = 3.9  $\mu\text{g}$   $\Sigma\text{PCBs/g}$  (25 pg TEQs/g)**
    - **Hepatic EC20 = 2.8  $\mu\text{g}$   $\Sigma\text{PCBs/g}$  (89 pg TEQs/g)**
    - **Hepatic EC50 = 4.4  $\mu\text{g}$   $\Sigma\text{PCBs/g}$  (151 pg TEQs/g)**

# Conclusions

- **EC20 based on the jaw lesion is 6-fold greater than LC20 based on kit survivability**
- **EC50 based on the jaw lesion is 1.7-fold greater than LC50 based on kit survivability**



**The conclusions and opinions presented here are those of the authors, they do not represent the official position of any of the funding agencies, the Hudson River Trustees or the United States. Funding provided by the Hudson River Trustees.**

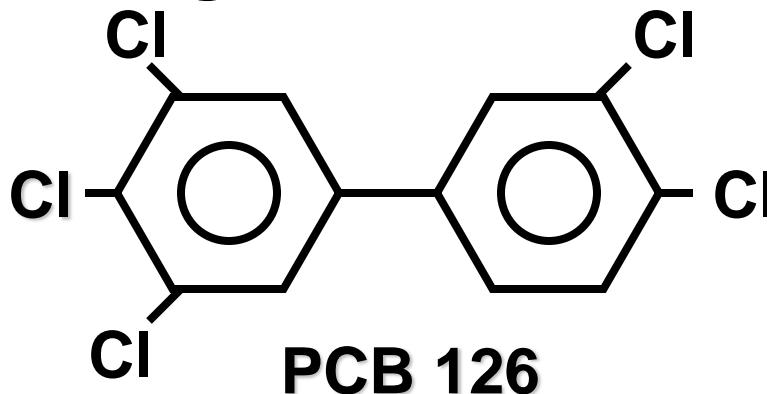
# QUESTIONS?



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# Jaw Lesion in Ranch Mink: Single Chemical

- Study designed to examine effects of PCB 126 on baculum development in juvenile male mink
- 12-week-old male mink fed diets containing 0 or 24 ng PCB 126/g feed for up to 70 days
- After 31 days, an animal observed having difficulty chewing



# **Jaw Lesion in Ranch Mink: Single Chemical**

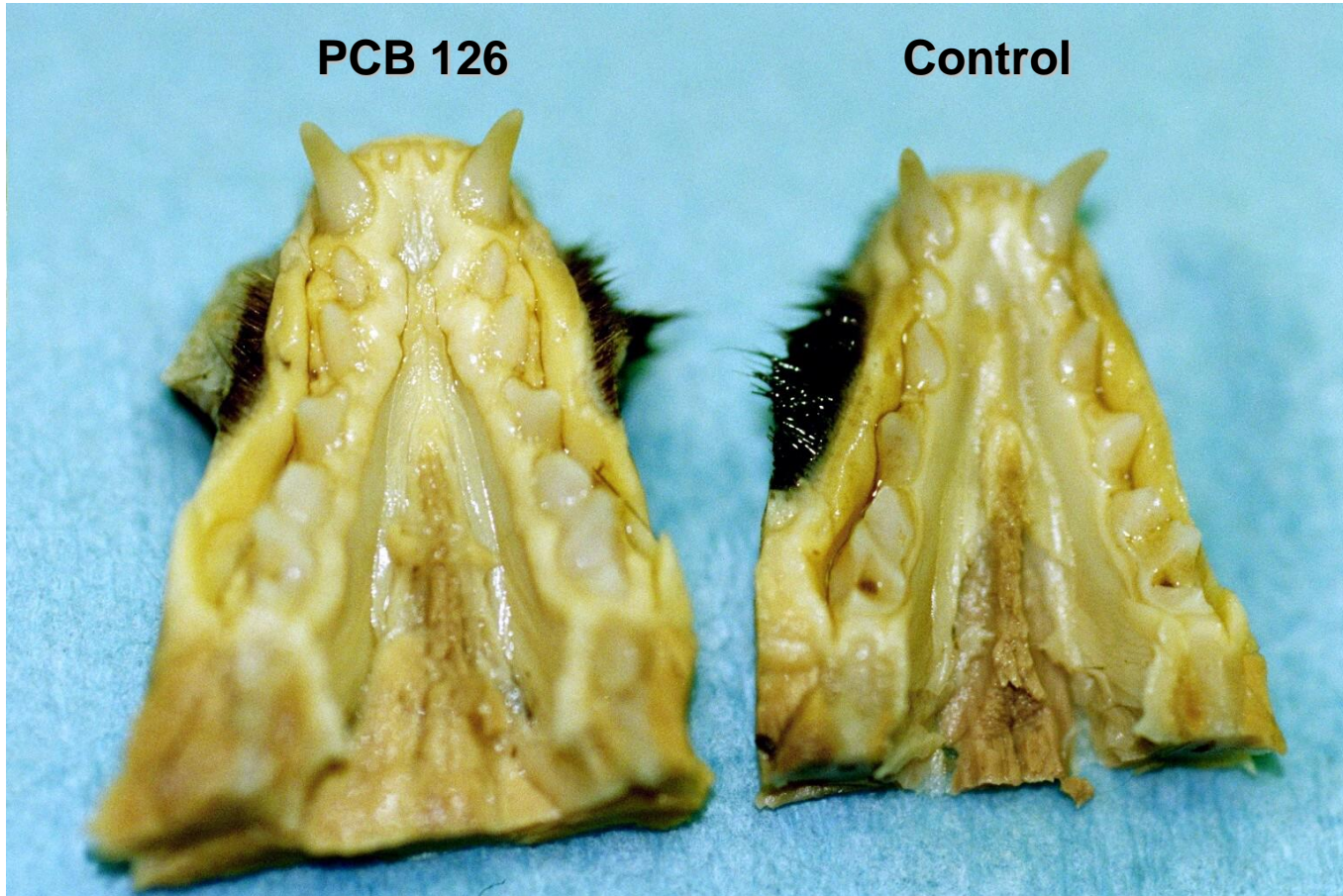
- **Gross displacement of incisor and canine teeth**
- **Swelling of mandibular and maxillary gingiva**
- **All 20 mink exposed to PCB 126 had lesion by day 70**

# Displacement and Loss of Teeth





# Gingival Thickening



# Osteolysis of Skull



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# Osteolysis of Skull



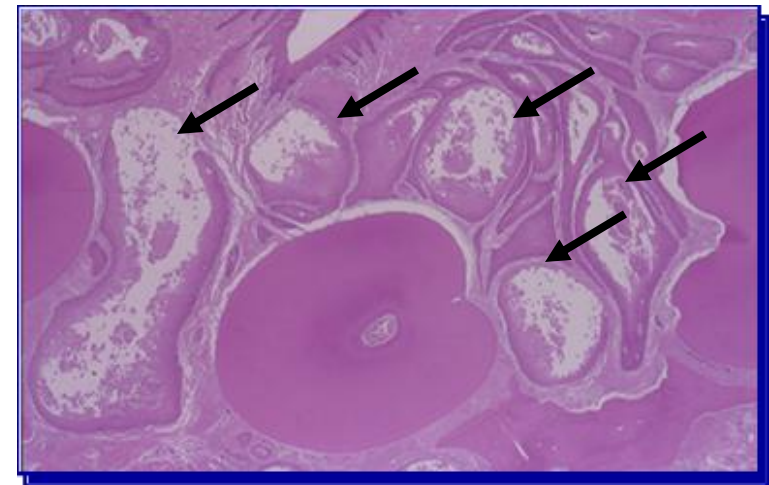


# Osteolysis of Skull



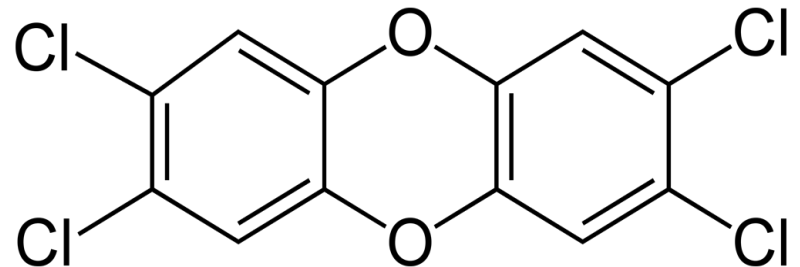
# Histological Evidence of the Lesion

- Nests and cords of squamous epithelial cells within the periodontal ligament of multiple teeth
- Extended into the adjacent alveolar bone



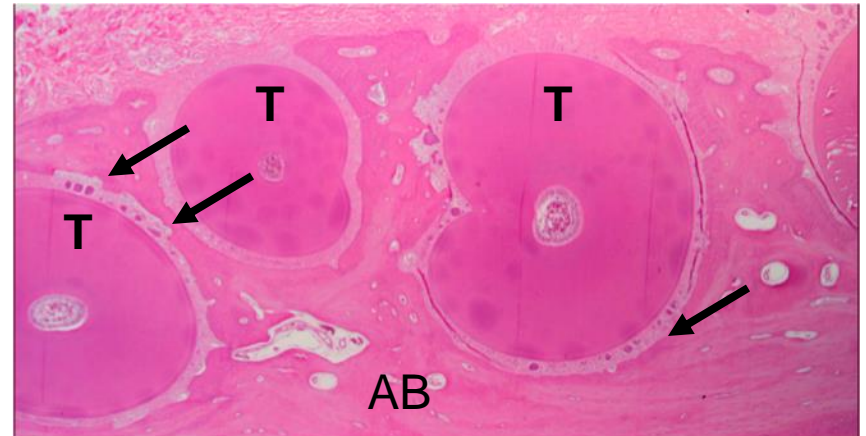
# Jaw Lesion in Ranch Mink: Single Chemical

- Could the lesion be induced by exposure to TCDD?
- 12-week-old mink fed diets containing
  - 2.4 ng TCDD/g
  - 24 ng PCB 126/g



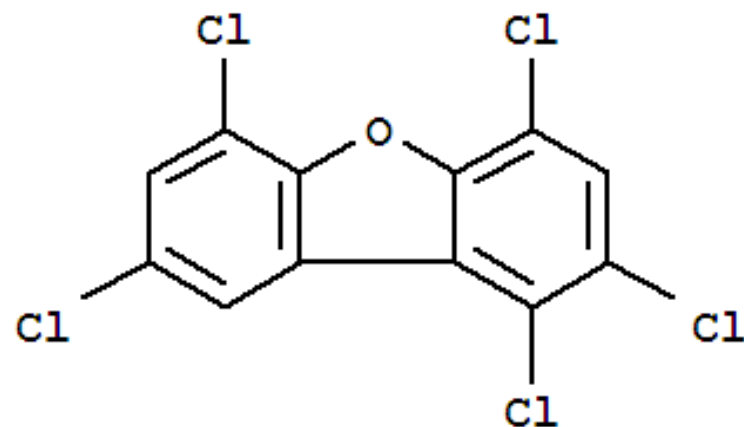
# Jaw Lesion in Ranch Mink: Single Chemical

- Gross displacement of the incisor and canine teeth by day 15 in both groups
- Histologically:
  - Nests of infiltrative squamous epithelium in the periodontal ligament
  - Loss of alveolar bone

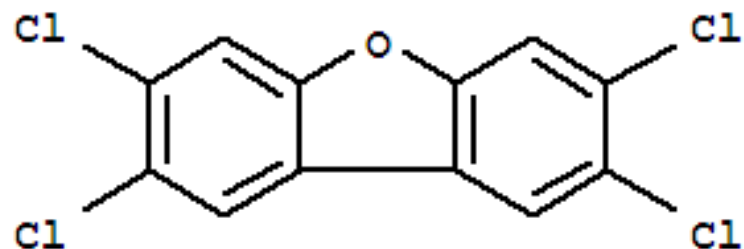


# Jaw Lesion in Ranch Mink: Single Chemical

- Could the lesion be induced by exposure to TCDD-like PCDFs?
- Reproduction trial assessing effects of exposure to environmentally relevant concentrations of:
  - TCDD
  - 2,3,4,7,8-PeCDF
  - 2,3,7,8-TCDF



2,3,4,7,8-PeCDF



2,3,7,8-TCDF

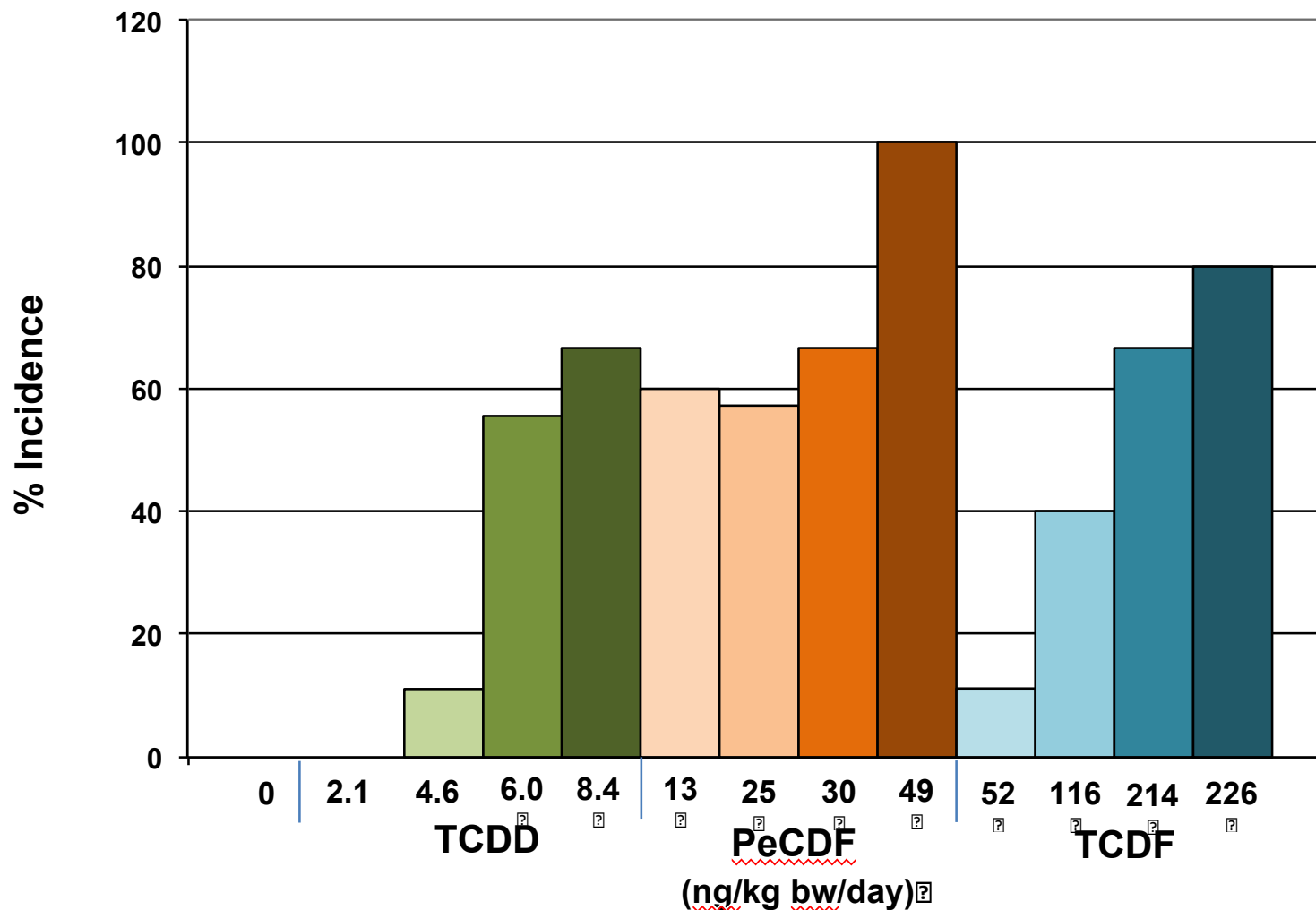


# Jaw Lesion in Ranch Mink: Single Chemical

- No effects on reproduction or kit survivability and growth
- Dose-related increase in incidence of jaw lesion in 30-wk-old juveniles



# Jaw Lesion Incidence in 30-wk-old Juvenile Mink



# **Jaw Lesion in Ranch Mink: Single Chemical**

- **Would the lesion progress after a defined exposure period?**
  - **Adult female mink were fed 24 ng PCB 126/g feed for 1, 2, 3, 4, or 5 wk**
  - **At the end of each exposure period**
    - **2 animals per group assessed for presence of lesion**
    - **2 animals per group placed on clean feed for 26 wk**

# Progression of Lesion

## WEEK 1

After 1 Wk of PCB 126



After 26 Wk of Clean Feed



# Jaw Lesion in Ranch Mink: Fish Feeding Studies

- Can jaw lesion be induced in ranch mink exposed to environmentally-derived TCDD-like chemicals





# Jaw Lesion in Ranch Mink: Fish Feeding Studies

- Fish (carp) collected from river of interest
- Incorporated into mink feed at specific  $\Sigma$ PCB and TEQ concentrations
  - Represent quantity of fish consumed by wild mink (10-70%)
  - Represent quantity of PCBs/TEQs predicted to be consumed by mink residing in area of concern



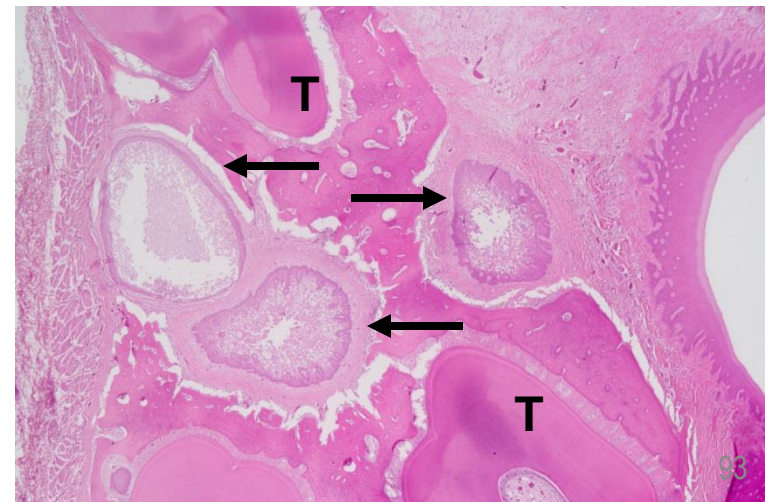
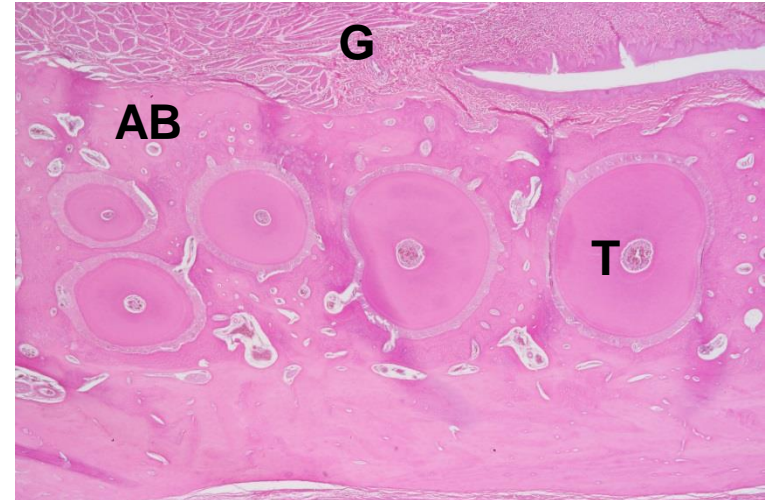
# **Jaw Lesion in Ranch Mink: Fish Feeding Studies**

- **Diets fed to female mink from 8 wk prior to breeding through weaning of kits (approximately 160 days)**
  - **All adult females and a sample of kits necropsied when kits 6 wk old**
  - **Sample of kits maintained on respective diets for an additional 160 days (30 wk of age)**



# Saginaw River

- Contaminated with:
  - PCBs from automobile manufacturing
  - PCDDs and PCDFs from chemical manufacturing
- No effects on reproduction or kit survivability
- Jaw lesion in 30-wk-old juveniles
  - 4 of 8 animals at 1.1 $\mu$ g  $\Sigma$ PCBs/g feed (48 pg TEQs/g feed)
  - 6 of 8 animals at 1.7  $\mu$ g  $\Sigma$ PCBs/g feed (73 pg TEQs/g feed)





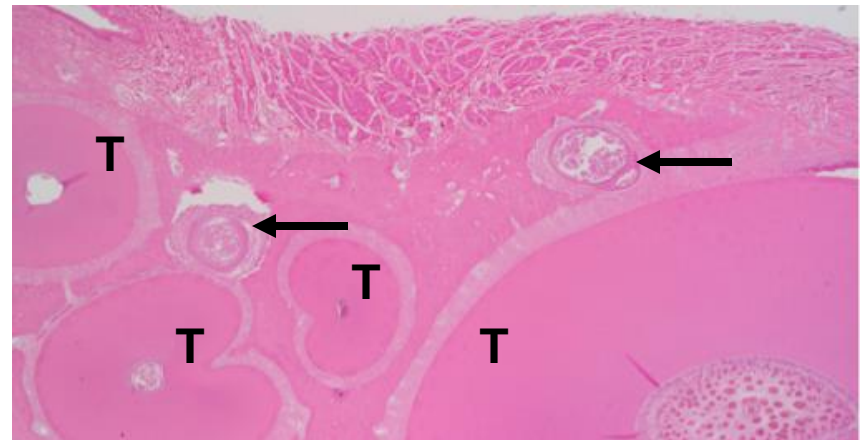
# Housatonic River

- **Flows from western Massachusetts and Connecticut into Long Island Sound**
- **Portion of the river contaminated with PCBs originating from a facility that manufactured electrical transformers**

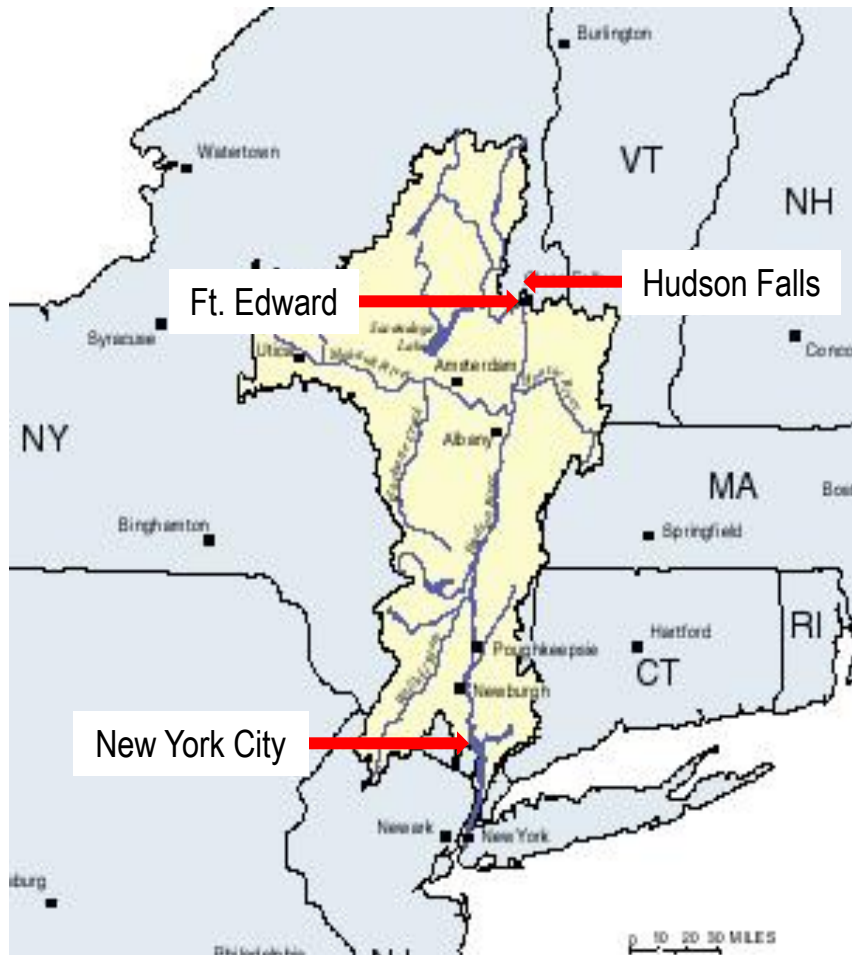


# Housatonic River

- **Reproductive performance**
  - Decreased survivability of mink kits between 3 and 6 weeks of age at  $3.7 \mu\text{g } \Sigma\text{PCBs/g}$  ( $69 \text{ pg TEQs/g}$ )
- **Jaw Lesion**
  - 1/6 animals at  $0.96 \mu\text{g } \Sigma\text{PCBs/g}$  ( $9 \text{ pg TEQs/g}$ )
  - 2/6 animals at  $1.6 \mu\text{g } \Sigma\text{PCBs/g}$  ( $16 \text{ pg TEQs/g}$ )
  - **6/6 animals at  $3.7 \mu\text{g } \Sigma\text{PCBs/g}$  ( $69 \text{ pg TEQs/g}$ )**



# Hudson River



- Contaminated with PCBs from Ft. Edward to New York City
  - Electrical transformer manufacturing facilities at Ft. Edward and Hudson Falls

# Hudson River

- **Reproductive performance**
  - **Stillborn kits**
    - **↑** at  $4.5 \mu\text{g } \Sigma\text{PCBs/g}$  ( $28 \text{ pg TEQs/g}$ )
  - **Kit survivability**
    - **↓** at  $2.8 \mu\text{g } \Sigma\text{PCBs/g}$  ( $19 \text{ pg TEQs/g}$ ) at 6 wk of age
  - **Kit growth**
    - 6 wk body mass **↓** at  $1.5 \mu\text{g } \Sigma\text{PCBs/g}$  ( $10 \text{ pg TEQs/g}$ )





# Hudson River

- **Jaw lesion in adults**
  - 1/14 at  $0.72 \mu\text{g } \Sigma\text{PCBs/g}$   
(5.1 pg TEQs/g)
  - 2/15 at  $1.5 \mu\text{g } \Sigma\text{PCBs/g}$   
(10 pg TEQs/g)
  - **4/14 at  $2.8 \mu\text{g } \Sigma\text{PCBs/g}$   
(19 pg TEQs/g)**
  - 12/18 at  $4.5 \mu\text{g } \Sigma\text{PCBs/g}$   
(28 pg TEQs/g)
  - 16/19 at  $6.1 \mu\text{g } \Sigma\text{PCBs/g}$   
(38 pg TEQs/g)



# Jaw Lesion in Wild Mink

- Does the jaw lesion occur in wild mink?
- If so, is the occurrence associated with the presence of contaminants?



# Rochester Embayment of Lake Ontario Area of Concern (REAOC)

- REAOC contaminated with PCBs, PCDDs and PCDFs
- 1/6 mink from REAOC had lesion
  - Gross evidence of lesion
  - Greatest concentration of hepatic PCBs (6  $\mu\text{g/g}$ )
- 0/6 mink from reference site had lesion





# **St. Regis Mohawk Tribe (SRMT) Reservation**

- **St Lawrence River in upstate New York**
- **PCB contamination from automobile company foundry**
- **1/11 mink had lesion**



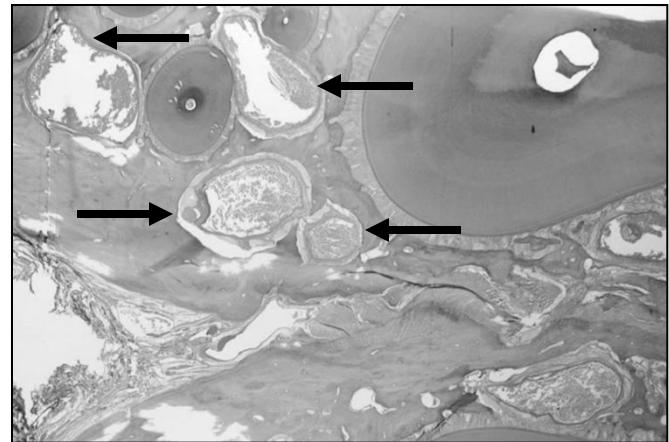
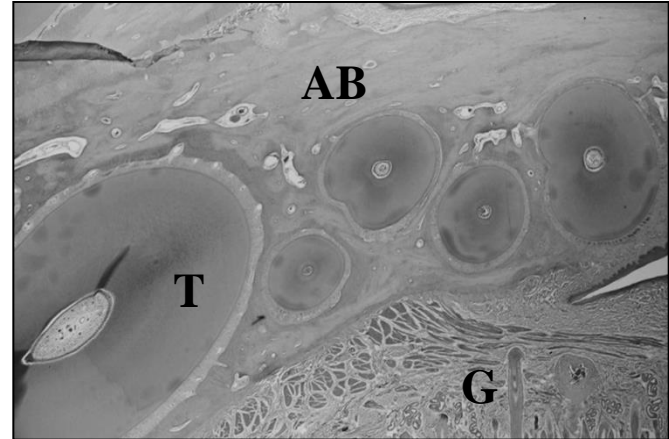
# **Kalamazoo River Area of Concern (KRAOC)**

- **KRAOC**
  - **80 mile stretch from Morrow Dam in Kalamazoo County to Lake Michigan**
  - **PCB contamination from recycling and processing of carbonless copy paper**



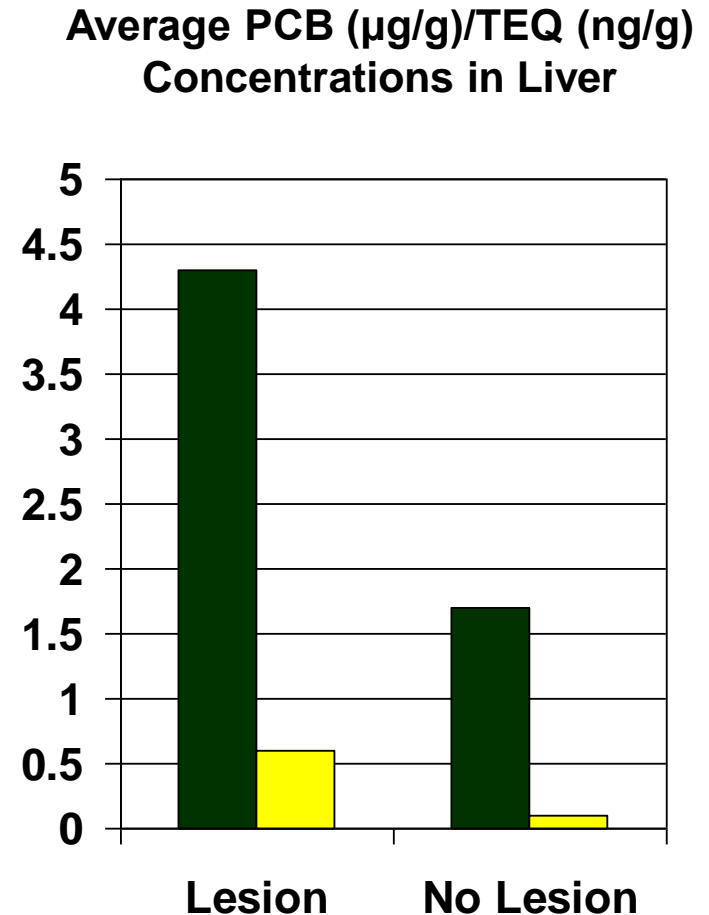
# KRAOC

- 4/9 mink collected from KRAOC had lesion
- 0/3 of the mink collected from the reference site had lesion



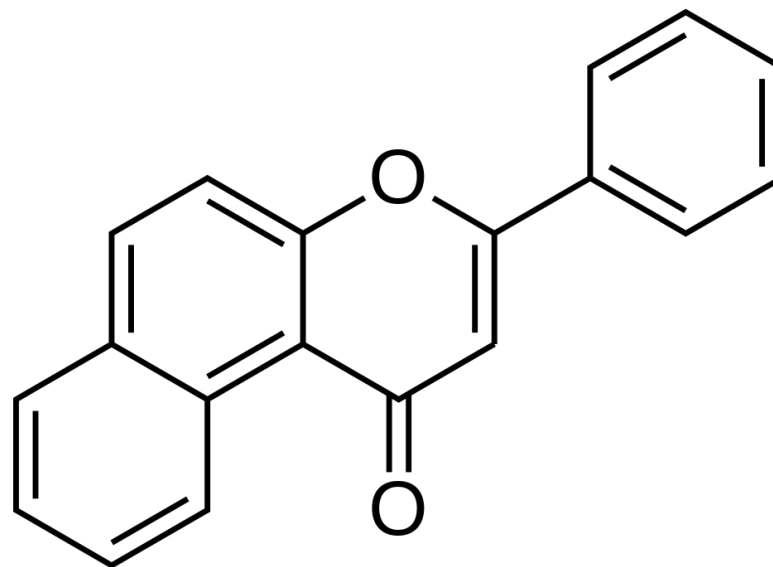
# KRAOC

- Lesion severity significantly correlated with hepatic concentrations of:
  - $\Sigma$ PCBs ( $r^2 = 0.88$ )
  - $\Sigma$ TEQs ( $r^2 = 0.89$ )



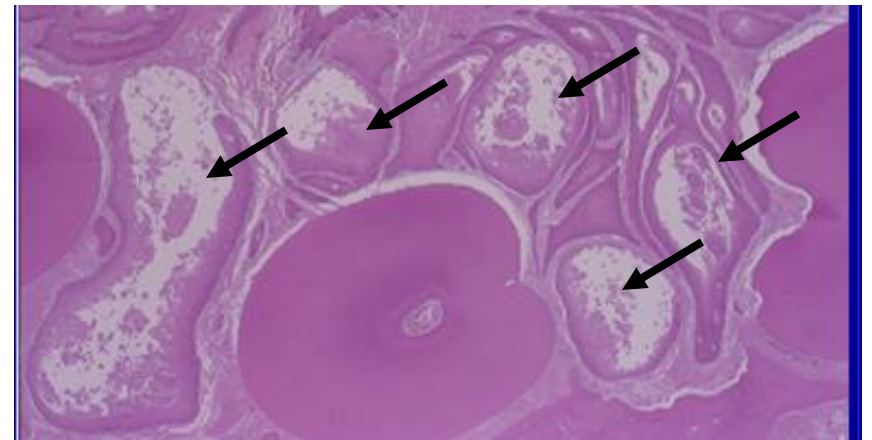
# Recent Studies

- Lesion induced by single ip injection of PCB 126
- Lesion induced by single ip injection of  $\beta$ -naphthoflavone
  - Ah receptor agonist
  - NOAEL = 0.4 mg/kg bw
  - LOAEL = 4.0 mg/kg bw



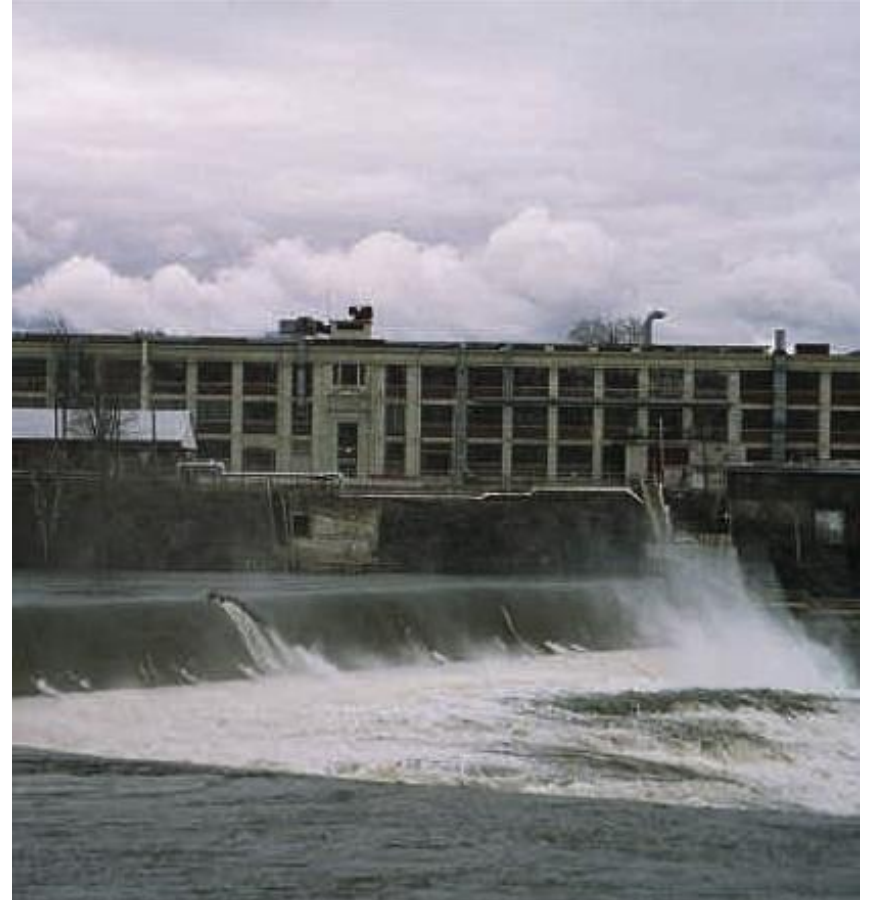
# Summary

- Gross and histological evidence of jaw lesion in mink after exposure to single TCDD-like chemicals in a controlled exposure situation
  - TCDD
  - PCB 126
  - 2,3,7,8-TCDF
  - 2,3,4,7,8-PeCDF



# Summary

- **Mink exposed to environmentally-derived TCDD-like chemicals from 3 different locations had histological evidence of the lesion**
  - **Saginaw River**
  - **Housatonic River**
  - **Hudson River**





# Summary

- **Wild mink collected from environments contaminated with TCDD-like chemicals had histological evidence of the lesion**
  - **Lake Ontario**
  - **St Lawrence River**
  - **Kalamazoo River**



# Conclusions

- **This jaw lesion could pose a threat to wildlife health and survival**
- **Because the lesion...**
  - **... can be induced by exposure to single TCDD-like chemicals in a laboratory setting**
  - **... can be induced by exposure to environmentally-derived mixtures of TCDD-like chemicals in a laboratory setting**
  - **... has been documented in wild mink collected in environments contaminated with TCDD-like chemicals**
- **... it has potential be used as an indicator of TCDD-induced damage in piscivorous mammalian species**

# Acknowledgements

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